



invisible  
teacher



# HOW MIGHT DIGITAL LEISURE GAMES FOSTER CRITICAL THINKING AND GRIT?

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A major research project presented to OCAD University in partial fulfillment of the requirements for the degree of Master of Design in Strategic Foresight & Innovation

Toronto, Ontario, Canada  
December, 2016



Vanessa Rementilla 2016

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# Abstract



The ubiquity of mobile devices and the rapid growth of mobile gaming have put digital games into the tiny hands of children, some under 2 years of age. What, if anything, are these games teaching our kids? Could they be learning essential skills that will be useful in the future—or are they just for fun? This research investigates if and how digital leisure games promote critical thinking and grit in children ages 9–12. It will explore game design, motivations of players, stages in child’s development and other factors that may influence learning outcomes. It aims to create a framework for identifying essential future skills and traits and provide future directions for parents and, potentially, educators and game developers.





DEDICATION

To Francis, Mateo and Zach

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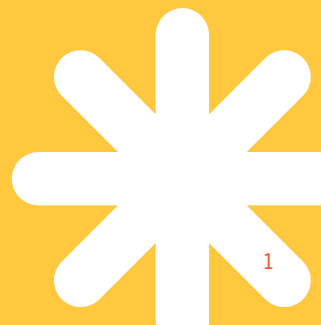
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# 1. Introduction



# Good Candy?



1.

I asked my 9-year-old son, Zach, “What’s a mobile phone for?” With a huge grin, he said, “For playing games!” He was half-joking. Kids tethered to mobile devices are a common sight, so it comes as no surprise that today’s children associate them with playtime. Children’s access to mobile devices like smartphones and tablets has never been higher. A Catalyst Canada study reveals that Canadian ownership of smartphones grew from 68% in 2015 to 76% in 2016. This national survey “paints a picture of a well-established and rapidly growing Canadian mobile landscape. Smartphones are no longer merely prevalent in Canada, but virtually ubiquitous” (2016). In the U.S., the trend is also increasing: nearly two-thirds or 64% of American adults own a smartphone, up from 35% in 2011 (*Pew Research*, 2015). What draws children to mobile devices? Games. The video game industry, consisting of PC, console and mobile-based games, boasts revenues surpassing the movie and music industry, with mobile expected to eclipse the other platforms in the next three years (Nath, 2016). Since 2015, the spotlight has been on mobile gaming because of accessibility, larger market size and cheaper pricing compared to the other platforms.

Cell phones used to be reserved for the individual use of a grown-up. As mobile technology became a stable platform for game development, parents like me are no longer the sole users of our own phones—we share them with our kids, who are always eager to play games on them. For some lucky tweens, access is a non-issue; they have their own smartphones! Of course, the natural consequence of access and ownership is an increase in time spent on these devices. And if mobile gaming is now an inevitable part of childhood, parents need to ensure that children are getting beneficial experiences from it. Not only through preventative curation—to stem age-old concerns of inappropriate content (among other concerns), but through proactive curation of learning. Every time we hand our phones to our kids, are we giving them an opportunity to learn or are we simply handing out the technological equivalent of candy? Are games considered a treat to pass the time and have fun? Or can digital leisure games<sup>1</sup> actually serve as beneficial tools for our kids?

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<sup>1</sup> Digital games created for entertainment; not produced for formal education or with specific content learning outcomes; played on mobile devices such as smartphones and tablets.

What are the important things kids should learn, anyway? According to educators, governments, business leaders, for-profit and non-profit organizations, our children need competencies beyond the traditional content taught in schools. To be prepared for the complexities and the constantly evolving economic landscape of the 21st-century, they need to develop critical thinking skills and grit.

Critical thinking is an objective way to form a judgement. It is a series of interconnected thinking skills that start with knowledge (identifying relevant information), comprehension (organization and selection of facts or ideas), application (use of facts, rules and principles), analysis (breaking into parts), synthesis (combining ideas to form a new whole) and evaluation (developing opinions, judgements, decisions). Ranked as a top cognitive skill in all 21st-century learning frameworks, it is a vital skill in student life and beyond.

Grit is a non-cognitive, intrapersonal trait that describes a person's serious determination to pursue a long-term goal. A gritty person can overcome failures and challenges in their life because their drive is supported by personal passion, perseverance and a clear direction. In recent studies grit was found to be a better indicator of GPA<sup>2</sup> and graduation rates (Duckworth, 2016).

This study will explore how digital leisure games might foster these two essential future competencies. If indeed digital games, with their immersive and engaging designs, can help foster critical thinking skills and grit, we may have uncovered a learning pathway that's fun and unforced: an invisible teacher.

## A WORD ON NOMENCLATURE

Throughout this document the words “digital games” and “video games” will be referenced. “Digital games” refers to downloadable or pre-installed games available as applications in mobile devices such as smartphones, tablets and other portable devices. “Video games” refers to games that are available from bricks and mortar or online retailers. They come in physical packaging or through online downloads and are played on consoles or computers. When both types of games are referenced, “Digital/video games” will be written. “Mobile devices” means portable electronic devices such as smartphones, tablets and other handheld gaming instruments.

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<sup>2</sup> Stands for Grade Point Average, it is an average of the grade point values students have earned in credit courses taken in a learning institution such as a university.



## 2. Methods and Techniques



## Methods and Techniques



Several methods were employed to gather information for this study. An extensive literature review was conducted which included futures research technique—Horizon Scanning. Auto-ethnography was used to investigate digital leisure games and online questionnaires were collected to augment parent perspectives culled from literature reviews and to test the learning framework.

### 2.1. Literature Review

A thorough examination of literature that intersects the mobile gaming industry and learning was conducted. While focusing on the intersection, topics within these domains and its periphery were studied where they were relevant. The Horizon Scan, in particular, focused on emerging and shifting topics, including issues that may be at the margins of current thinking, but provide opportunities for the future.

## KEY TOPICS INCLUDE:

### Gaming Domain:

- Mobile ownership, access and usage, especially among young children
- Mobile gaming statistics and the gaming landscape in general
- Mobile game design and genres
- The state of negative perceptions and issues
- The state of benefits and advocacy associated with gaming
- Parenting styles and perceptions

### Learning Domain:

- Game-based schools
- State of digital games as learning tools in K–12 classrooms; adoption, issues and challenges
- Future competencies children need to learn; frameworks, applications and issues
- Child development and other factors that affect game adoption
- Critical thinking and grit; relevance within digital/video games

Sources of literature review come from a wide variety of perspectives, including:

- Scholarly articles, journals and books from the field of medicine such as psychology and paediatrics
- Scholarly articles, journals and publications from the field of education, including universities, educational non-profit organizations, elementary and middle schools and teachers
- Publications by gaming, software and entertainment industry, computer scientists, research and analytics organizations and governments
- Articles, blogs, forums and videos from parenting, gaming, media and technology websites, including those featured from news corporations



Figure 1: Study Sources illustrates the comprehensive topics of study derived from a diverse set of sources.



## 2.2 Auto-ethnography

“Auto-ethnography is an approach to research and writing that seeks to describe and systematically analyze (*graphy*) personal experience (*auto*) in order to understand cultural experience (*ethno*)” (Ellis, C., Tony, A. E., & Arthur, B. P., 2011). The researcher played 15 digital leisure games in order to best understand and assess each one. Each game was played until high levels were reached or in some cases, finished in its entirety. The selection of the games is based on the following criteria:

- Digital leisure games made for smartphones and tablets (iOS, Android).
- Commercial success: Top-grossing game within the last five years.
- Critical acclaim: Favourable reviews by top-gaming/rating websites such as Metacritic, Gamespot and iTunes.
- Age-appropriate: Must be rated for at least 9 years old and up.
- Games kids play with multiple mentions, based on responses in the parent questionnaire (Section 6.1.2, p. 41); in most cases, these games are also a commercial and critical success.
- Games that span various mobile game genres and also fit the criteria above. In several cases, genres like “casino” or “action,” such as shooter and role-playing games were not considered due to the unsuitable nature of the content. The sports genre was also not considered as these games are typically digital simulations of the real-world game.

The digital games chosen run the spectrum of high, moderate and low learning outcomes based on the researcher’s assumptions and expectations. Without having played any of these games, the learning outcomes are solely based on initial knowledge of the game genre(s), descriptions and personal perceptions.

Table 1 outlines the 15 digital leisure games, their genres and the learning expectations:

**Table 1:** 15 Digital Games Reviewed, Genres, Learning Expectations

Game	Genre	Expectations (Critical Thinking / Grit)
Candy Crush Saga	Puzzle (Matching)	L/H
Clash Royale	Strategy / Tower Defence / Card Battle	M/H
Crossy Road	Endless Arcade	L/L
Cooking Fever	Simulation / Time Management	L/M
Fruit Ninja	Arcade (General)	L/M
Human Resource Machine	Puzzle / Logic	H/M
Mimpi Dreams	Puzzle / Adventure / Platformer	M/L
Minecraft	Sandbox / Action Builder	H/H
Monument Valley	Puzzle / 4D	M/M
Pac-Man 256	Endless Runner / Arcade	M/H
Piano Tiles	Music / Arcade	L/H
Plants vs. Zombies	Strategy / Tower Defense	M/H
Pokémon GO	Action Battle / Augmented Reality	L/H
Slither.io	Arcade	L/H
Stick Hero	Arcade / Physics	L/H

**Note.** Level of Skill: L= Low, M=Medium, H=High. Game genres are not always definitive. Some are a hybrid of several different genres.

While at play, the following game design elements (GDE) and attributes are being noted and investigated:

- Inventory of the general game mechanics (constructs of rules, methods)
- Inventory of elements such as characters/avatars, data sets, customizable settings, rewards and other elements that impact outcomes
- Understanding of the game genre and how it affects overall gameplay (i.e. strategy games require managing multiple elements, often concurrently)
- How and if challenges unfold and scale up; what new elements are added? Is information scaffolded or overtly explained?
- What commitment and involvement is being asked of the player, based on time, pace, cognitive functions and general disposition; does it make the player return?
- What roadblocks, like paywalls or time-based constraints, are present and how do they affect learning critical thinking and grit?
- Social aspect for multiplayer games; how do they allow collaboration, motivation and how does that affect overall gameplay?

As part of post-play reflection, the GDE and attributes were aligned with the definitions of critical thinking and grit. These eventually formed the learning framework that was created to identify skills in each game (Sections 8 and 9 respectively). GDE for each game were identified and scored. This formed the basis of the game reviews (Appendix A, p. 127). In the course of gameplay, the researcher also referenced external resources such as game blogs, articles, forums and videos to help acquire knowledge and accelerate know-how.

## 2.3. Online Survey Questionnaires

InvisibleTeacher.com, a companion website to this research, was developed to share study information, conduct survey questionnaires and present findings. The following surveys were conducted through the website.

### 2.3.1 PARENT QUESTIONNAIRE

To augment the literature review, a Parent Questionnaire was cross-posted in parenting, child advocacy and media websites, digital/video game review and online forums, and through the researcher's Facebook page which is comprised of at least 75% parents with children who play digital games. The

Parent Questionnaire seeks to understand current parenting practices and perceptions in digital gaming including:

- Parent's knowledge of the digital games their child plays
- Game acquisition methods and practices
- Conditions, rules and challenges around screentime as it relates to digital gaming
- Perceptions on what their children might be learning through digital games

The online recruitment post led self-elected participants to the researcher's website, InvisibleTeacher.com, where participants filled out the questionnaire and the completed data was sent to the researcher for compilation. Participants were required to be parents with children between the ages of 9–12 who play digital leisure games on mobile devices. This survey received 16 responses based on a target of 10–20 participants. The responses gathered were analyzed to show general direction or themes.

### 2.3.2 LEARNING FRAMEWORK SURVEY

The 15 digital leisure games reviewed was scored using the Learning Framework developed to identify critical thinking and grit (Sections 8 and 9 respectively). The scores for critical thinking and grit, along with a text explanation, were combined to create individual game reviews. To gain feedback on the Learning Framework, a survey sharing the game reviews and an explanation of the Learning Framework was posted on Invisibleteacher.com. Similar to the Parent Questionnaire (Section 6.1, p. 40) the survey invitation was cross-posted online on the aforementioned websites. Self-elected participants were redirected to InvisibleTeacher.com to fill out the survey. Participants were required to be parents with children between the ages of 9–12 who play digital leisure games on mobile devices. This survey received 10 responses based on a target of 10–20 participants.

The survey seeks to understand the following:

- Parent's choice of digital leisure games for their children given the ratings of how each game can foster critical thinking and grit.
- Whether parent perceptions about the games have changed or not based on critical thinking and grit scores.
- The most important factors parents consider when choosing games for their child.
- Feedback on the Learning Framework; whether parents find it useful in curating their child's digital games.



### **3. Context and Rationale**



## Context and Rationale



### 3.1 Mobile is the New Playground

#### CAN I PLAY ON YOUR PHONE?

Whether it's a hand-me-down or the latest smartphone, some children receive their first cell phone at the age of 10, according to Influence Central's Study on Kids and Tech (2016). And while device ownership starts at a young age, usage starts even younger. 38% of children under 2 years old have used a smartphone, tablet or similar device for playing games, watching videos or other media-related purposes. This usage increases to 72% by the age of eight (*Common Sense Media*, 2013).

Indeed, mobile devices have become a de facto standard for children's entertainment. On car trips, DVDs have taken a back seat (35%) to smartphones (45%) and tablets like iPads (55%). Slipping to a distant fourth is the once popular portable game device Nintendo DS (24%) (*Influence Central Kids and Tech Study*, 2016). When it comes to digital games, kids aged 2–17, prefer to play on smartphones and tablets over consoles; 63% of the kids say they play games on a smartphone (Whitney, 2015).

Not only is the usage of smartphones and tablets increasing, but children are also spending more time on these devices. Some reports have kids aged 8- to 12-years-old playing for almost two hours a day (*Common Sense Census: Media Used by Tweens and Teens*, 2015). Others corroborate those numbers, reporting that kids aged 2–17 play for an average of six hours per week (*NPD Group Report*, 2015). Liam Callahan, NPD Group analyst, notes the most surprising shift in the 2015 gaming practices is that kids are moving away from PCs. “In the past, the computer was considered the entry point for gaming for most kids, but the game has changed now that mobile has moved into that position. This may be related to a change in the behaviour of parents that are likely utilizing mobile devices for tasks that were once reserved for computers” (as cited in Whitney, 2015).

The ownership of mobile devices among families may also be changing parental practices. In the U.S., 60% of parents admit to using a smartphone, tablet or an iPod as a virtual nanny—a way to keep their child occupied, especially when they need to get something done (Richter, 2013).

## **MOBILE GAMING: LEVELLING UP AND UP**

The rise of mobile gaming is said to be responsible for the declining sales of Nintendo DS and the demise of Sony PlayStation’s portable gaming devices, PSP and PS Vita (Alpeyev & Amano, 2016; Kohler, 2016). With the pervasiveness of smartphones and their high-quality game offerings, it’s harder to justify the need for another portable gaming device. Ray Bautista, Head of Business Development and Branding of Turbo Studios, believes, “Mobile gaming is the future simply based on the accessibility of the platform” (as cited in Moir, 2016).

Frye traces the advent of the mobile gaming takeover to 2008 and the release of the iPhone 3G and the launch of the Apple App store. He believes the iPhone’s high-processing power, efficient touchscreen and online connection carved a new path for game development (2016). Earlier mobile games attracted casual gamers but deterred serious players as they considered mobile games to have throw-away quality. In the last few years, however, the development of near-console quality games released on smartphones are capturing mid-to-hard-core gamers, further increasing the share of players.

“With the success of games like Vainglory, Hearthstone and Clash Royale to name a few, we can already start to see how the mobile game audience is demanding higher quality production values and community-focused game features like PVP (Player vs. Player) and RPG/CCG (Role Playing Games/ Custom Combat Games) elements as well. It’s just a matter of time before triple-A quality games on



mobile becomes the norm. Content is king and as long as the platform has the games, the gamers will follow,” said Bautista (as cited in Moir, 2016).

Further, the free-to-play or “freemium” pricing model, which allows free game downloads financially supported by in-game advertising or in-app purchases, attracts users who would not usually try games—a gaming industry model unheard of before the iPhone came out (Frye, 2016).

Big game developers like Nintendo, who have long positioned themselves as a console business reluctant to enter the mobile industry, announced in early 2015 a partnership with Japanese mobile gaming firm, DeNA to further their intellectual property and audience (Gaudiosi, 2015). As a company known to be indecisive on their mobile stance, Nintendo is said to be rethinking their mobile strategy (Yamazaki & Wagstaff, 2016) after positive acceptance of their first mobile application, Miitomo (Awotowi, 2016) and the unprecedented success of Pokemon Go in partnership with developer, Niantic (Alpeyev & Amano, 2016).

With the largest number of gamers (1.9 billion) and largest market revenue (US \$36.9 billion), mobile, which includes smartphones and tablets, is the fastest growing segment of the games industry (“Newzoo.com,” 2016). It has mass appeal, engaging casual and core gamers alike and is a very accessible platform for gamers.

## 3.2 Gaming Goes to School

### WHO'S GAME?

The popularity of teacher gaming blogs like GamingEdu and Minecraft Teacher, along with hundreds of YouTube channels devoted to game tutorials, signal a growing contingent of educators embracing digital games as part of their lesson plans.

The A-Games Project by the University of Michigan and New York University revealed in their nationwide survey of K–12 U.S. teachers that more than half are using digital games weekly or more often for teaching. A majority express moderate comfort in using games as part of their learning tools (Fishman, B., Riconscente, M., Snider, R., Tsai, T., & Plass, J., 2014).

Similarly, Level Up Learning: A National Survey on Teaching with Digital Games showed a majority of teachers are using digital games in their classrooms. Educational games remain more popular among

educators than commercial off-the-shelf (COTS) games with “8% of game-using teachers saying their students mostly play a hybrid of the first two options—entertainment games that have been adapted for educational use” (2014).

Minecraft is a popular example of that hybrid option. The sandbox<sup>3</sup> game, in which 3D blocks are used to create anything from towers to entire cities, was released in 2009 for the commercial market. It was never designed for education. Jens Bergensen, the lead Minecraft developer, says, “We have never done things with that sort of intent. We have always made the game for ourselves” (as cited in Thompson, 2016). By 2011, educators like Joel Levin (a.k.a. Minecraft Teacher) saw the learning potential embedded within the game and quickly adapted it to his teaching practice. Levin, the co-founder of Teacher Gaming, a game development company that seeks to further game-based learning in schools co-developed the first official “school-ready remix” MinecraftEdu, with maker Mojang. Since the US \$2.5 billion sale of Minecraft to Microsoft in 2014, a newer version called Minecraft Education Edition was released in early 2016 with additional features aimed at practical classroom use.

In the seven years since its release, Minecraft continues to be a sensation inside and outside of classrooms. Monica Ekman, a teacher at Viktor Rydberg school in Stockholm, Sweden says, “They learn about city planning, environmental issues, getting things done and even how to plan for the future” (Gee, O., 2013). Three years ago, Viktor Rydberg made Minecraft a compulsory subject for 13-year-olds. Schools around the world are also using Minecraft for teaching different subjects from geography to math to creative writing. Here are some examples:

- At Dalewood Middle School in Hamilton, Ontario, students learn city planning by using Minecraft to re-envision unused, post-industrial land north of the city (Ruf, 2013).
- Liam O'Donnell, a Toronto-based teacher and book author, uses Minecraft as a springboard to get students writing. He uses it for pre-game playwriting, drawing maps and diagrams to explore student ideas, making walkthroughs and guides to share information with peers and writing post-game play reflection through journals or a collective wiki (2012). O' Donnell is the founder of GamingEdu, an online resource for teachers using Minecraft in the classroom.
- Other teachers also use Minecraft's “large maps to demonstrate population displacement in geography lessons and its varied biomes to discuss the growth of plant life on earth. There's also Red Stone, an element in Minecraft that's been used to create everything from simple railway

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**3** A game genre that allows players to roam and change the virtual world at will. Also goes by the terms “open-world” or “free-roaming game”.

switching systems to fully working computer systems. The principles of Red Stone--being so similar to that of real-world circuits and logic gates--mean that some teachers have found it a compelling way to demonstrate electronics to students" (Walton, 2015).

O'Donnell shares, "Minecraft works because it was not created for teaching" (as cited in Zaidi, n.d.). He refers to the child's orientation of the game as something they play for fun, outside of school. Similarly, other teachers express why COTS games can be more attractive to students, "The more a game maps definitively to common-core standards the less game-like it becomes and the more it resembles educational software" suggesting that educational games can be less engaging (as cited in Schwartz, 2014). Indeed, the main distinction between COTS and educational games is that the former is designed for fun and entertainment, the latter with distinct learning outcomes which may dilute its fun factor.

Paul Darvasi, a high school English and media studies teacher and lifelong gamer based in Toronto, Ontario, shares, "There are now many examples of commercially successful games being adapted to classroom use, including Spore, Little Big Planet and SimCity. These games engage with mechanics that promote socialization, creativity, design, critical thinking and problem solving. Other examples include Sid Meier's Civilization and Assassin's Creed to teach history, World of Warcraft for math, writing and second language instruction, Portal for learning STEM and Minecraft to teach, well, just about everything" (2014).

## THE BRAVE, NEW GAME-BASED SCHOOLS

While we see gains in traditional schools adopting digital games in the classroom, there are a handful of schools betting on a fully-fledged game-based learning educational model. These schools' curriculums are delivered using innovative methods of learning through games.

- **Quest to Learn, New York, New York**

In 2009, the non-profit organization, Institute of Play, launched the New York City Public School, Quest to Learn. It uses game-like approaches and narratives with goals of increasing student engagement and outcomes. The Institute of Play shares that Quest has a 94% student attendance and a 90% average teacher retention rate (2016). Based on research from New York University, "Middle and high school students achieve significant growth in critical thinking, reasoning, problem-solving and communication skills" ("Q2L.org," 2016).

- **PlayMaker, Santa Monica, California**

PlayMaker school was created out of a partnership between New Roads School and education non-profit, GameDesk. It aimed to close the achievement gap between high and low-income schools and to engage students, particularly those who are not proficient in the STEM (Science, Technology, Engineering and Math) fields. It embeds STEM content into games and focuses on fostering a student's sense of purpose, ownership and personal relevance ("playmaker.org," n.d.). The school operated for two full academic years till 2014. Two teachers, among them co-founder, Tedd Wakeman, have moved on to start Sycamore School in Malibu, California under similar 21st-century pedagogical tenets, which include gaming (Higgin, n.d.).

- **EPIC, Oakland, California**

EPIC middle school, a STEAM<sup>4</sup> school in Oakland, California, employs not only a game-based approach to its curriculum, but "gamifies" the entire student experience. Students earn points and badges to "level up" their learning. They don't receive grades; instead, they move on to more challenging tasks once they have mastered the previous ones (Schwartz, 2014).

With the common belief that low student engagement is a core issue among traditional schools, these schools approach learning with an emphasis on constructivist methods—active, hands-on, immersive experiential learning. They adopt a student-led inquiry model as opposed to the traditional teacher-directed approach. Their innovative ways of learning through making, game-playing, systems thinking and engaging in the dialogic inquiry are some of the methods they believe are critical to preparing students for 21st-century competencies.

## ISSUES AND CHALLENGES

Despite the growing popularity of digital games being used in classrooms, educators still face many challenges:

- **Lack of Formal Training and Support**

Teachers acknowledge they are learning a new way of teaching and that formal training and support are lacking. They gather knowledge from interacting with peers and engaging in self-teaching, such as reading online resources. The growth of informal online communities on digital games for learning, mostly authored by game-using teachers, is evidence that teachers

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<sup>4</sup> An educational approach that includes the fields of Science, Technology, Engineering and Mathematics together with Art.

have self-assembled to address the lack of formal support from their districts. Without any professional development, they may be missing out on a range of teaching strategies, resources and games integration know-how (Takeuchi & Vaala, 2014). Further, some teachers report there is still a lack of support from parents who fret about screentime and misunderstand the use of games, believing it is the only means of classroom instruction (O'Malley et al., 2016).

- **Integration into Curriculum is Hard**

Teachers use games mostly to augment their material and rarely as the central instructional piece. Teachers express that game integration is hard; those who do not yet use digital games are “not sure how to integrate games” into their teaching, suggesting this uncertainty can be fraught with risks. And, a majority of digital game-using teachers wish it were easier to find curriculum-aligned games. Just 39% believe a sufficient variety of such games even exist (Fishman, B., Riconscente, M., Snider, R., Tsai, T., & Plass, J., 2014; Takeuchi & Vaala, 2014). Other teachers say that the process of game-based learning is challenging and that no amount of preparation can be sufficient for enacting game-based dialogic<sup>5</sup> facilitation with students. Chee, Mehrotra & Ong (2014) note, “A teacher’s capacity develops with practice over time”.

- **Teachers' Shifting Role and Limitations of Personal Background**

With teachers accustomed to delivering curriculum with a predetermined lesson plan, game-based learning, which lends itself to a dialogic pedagogy, marks a shift in teaching practice. Some teachers are uncomfortable and need to adjust to their new role as they feel the power shift from themselves to their students (Chee, Mehrotra, & Ong, 2014).

In the U.S. and Canada, the average age of elementary teachers is 40 years old (“Servicecanada.gc.ca,” 2011; Takeuchi & Vaala, 2014). If these teachers grew up with positive gaming experiences in the age of Atari, there’s a high chance they might use digital games in the classroom. However, the adoption of digital games in education is dependent on the teachers' personal experience, familiarity and comfort level with it (O'Malley et al., 2015; Takeuchi & Vaala, 2014).

- **Time Constraints**

With an already jam-packed curriculum, teachers typically use short-form games that can be accomplished within the class period. Teachers worry about the time it takes to play games and

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<sup>5</sup> A learning processes in which teacher and pupils critically interrogate the topic of study, express and listen to multiple voices and points of view, and create respectful and equitable classroom relations (“Dialogicpedagogy.com,” 2016).

the explicit instructional standards being met. “Few teachers are using learning games of the immersive variety, the kind that lend themselves to deep exploration and participation in the types of activities that set digital games apart from more didactic forms of instruction,” writes Lori Takeuchi in the executive report of Level Up Learning (2014).

- **Technical Issues**

Some schools may not have the proper servers, network capacity or sufficient number of computers or tablets. To offset the lack of devices, some school boards in Ontario, Canada have adopted the Bring Your Own Device Program (BYOD) as a common practice (Chen, B., Gallagher-Mackay, K., & Kidder, A., 2014).

- **Assessment**

No single framework guides teachers to reliably assess learning through digital games. Each game has a unique design and usage, so learning needs to be evaluated differently. Even among educational games, teachers stress about having to configure administrative settings individually when they are available. Barry Fishman, a professor at the University of Michigan School of Information and the School of Education shares from his study on educational games, “The most surprising finding for me was that the most common mechanisms in games for reporting progress--things like points and stars--are not that useful for teachers... For many of the teachers, it was hard to tell from these progress markers what the students were learning” (2016). The impetus to develop assessment tools for digital games is driving educational gaming advocates like GlassLab and GameDesk to seek their own methods. Glasslab works with SRI International, an independent research centre, to apply evidence-centred design (ECD) in creating assessments that address the needs of both students and teachers to act as a reliable, actionable data. “This describes a deliberate effort to produce activities in the game which can produce evidence that lets you make inferences about a player’s knowledge and skills. Since we can’t peer into everyone’s head and see what they know, we have to infer it from evidence” (Escuadra, 2015).

GameDesk also acknowledges that while the non-traditional methods of learning through games are useful for fostering STEM content, there’s still a dearth of assessment tools that can help show learning outcomes and student growth. They are developing Learning Lens, “a mobile assessment tool that enables educators to capture observations and design assessments around unique and emergent 21st-century learning experiences such as project-based learning, games, apps in class and DIY/maker activities” (“Gamedesk.org,” 2016).

### 3.3 Searching for the Skills of Tomorrow

#### IT'S THE FUTURE... BUT NOT AS WE KNOW IT

Since the 1980s, research conducted by governments, business organizations, educational non-profits and academics have made us aware of the imperative to reform educational systems. In the U.S., scores from assessment exams such as the National Assessment of Educational Progress (NAEP), Trends in International Mathematics and Science Study (TIMSS) and Programme for International Student Assessment (PISA) prove high school students are “struggling to achieve the skills necessary to participate in a global economy” (*A Crosswalk of 21st Century Skills*, 2011).

Many point to the rapid growth of technology which has reshaped the way we communicate, the way we work and created new types of jobs we did not foresee. “... [There are] changes in the workforce from an industrial model of production to a rapidly transforming, technology driven and interconnected globalized economy. Such an economy requires competencies suited to dynamic and unpredictable models of economic and social development” (*21st Century Competencies*, 2016). Students need to be equipped with future competencies to access emerging jobs and those that are not yet known.

Further, there is growing evidence that learning can be enhanced with the use of technology to foster digital citizenship and information literacy and to create immersive, transformative learning. Learners are also demanding their education be “more connected and relevant to their everyday lives” (*21st Century Competencies*, 2016).

In addition to many other international organizations, the Organisation for Economic Co-operation and Development (OECD) has called on international governments to “make an effort to properly identify and conceptualise the set of skills and competencies required so as to incorporate them into the educational standards that every student should be able to reach by the end of compulsory schooling” (Ananiadou & Claro, 2009, p. 5).

The result of this call is the creation of 21st-century learning frameworks which are typically born from a collaboration of multiple stakeholders, including policy makers, governments, educators, school boards, the business community and non-profit organizations. The frameworks, while unique to each school board, district, state/province or country, have common themes and goals. Each is designed to equip students with future competencies—knowledge, skills and attributes that will prepare them to

face complex challenges of tomorrow, in addition to the necessary foundational skills of literacy and mathematics and core learning in other subjects.

## THE #1 SKILL NEEDED: CRITICAL THINKING

Critical thinking can be traced back to the teachings and practices of Greek philosopher Socrates about 2,500 years ago. His method of inquiry known as the “Socratic Questioning” is perhaps one of the best-known critical thinking strategies. Over time, many overlapping definitions have surfaced from various domains, including psychologists, philosophers and content specialists from the domains of literature, social studies, mathematics and science. Some of the definitions include:

**1941:** *“The ability to think critically... involves three things: (1) an attitude of being disposed to consider in a thoughtful way the problems and subjects that come within the range of one’s experiences, (2) knowledge and methods of logical inquiry and reasoning and (3) some skill in applying those methods.”* (Glaser)

**1986:** *“...the ability to analyze facts, generate and organize ideas, defend opinions, make comparisons, draw inferences, evaluate arguments and solve problems.”* (Chance)

**1989:** *“... A way of reasoning that demands adequate support for one’s beliefs and an unwillingness to be persuaded unless support is forthcoming.”* (Tama)

**1991:** *“... a conscious and deliberate process which is used to interpret or evaluate information and experiences with a set of reflective attitudes that guide thoughtful beliefs and actions.”* (Mertes)

**1992:** *“... the intellectually disciplined process of actively and skillfully conceptualizing, applying, analyzing, synthesizing and/or evaluating information gathered from, or generated by, observation, experience, reflection, reasoning or communication, as a guide to belief and action.”* (Scriven & Paul)

**2008:** *“Critical thinking is, in short, self-directed, self-disciplined, self-monitored and self-corrective thinking. It presupposes assent to rigorous standards of excellence and mindful command of their use. It entails effective communication and problem solving abilities and a commitment to overcome our native egocentrism and sociocentrism.”* (Paul & Elder)

Critical thinking is an essential attribute in education and the workplace today. Huitt argues, “Old standards of simply being able to score well on a standardized test of basic skills, though still appropriate, cannot be the sole means by which we judge the academic success or failure of our students.” (1998) Critical thinking is acknowledged in every 21st-century learning framework, assessed



as one of the most important “super skills” to have and is part of the 4Cs<sup>6</sup>, along with Communication, Collaboration and Creativity.

“The knowledge and digital era is demanding people with higher order thinking skills; the ability to think logically and to solve ill-defined problems by identifying and describing the problem, critically analyzing the information available or creating the knowledge required, framing and testing various hypotheses, formulating creative solutions, and taking action” (C21 Canada, 2012, p.10).

This study will use the definition of Reichenbach (2002): Critical thinking is a group of interconnected skills that allows one to analyze, creatively integrate and evaluate information—a thinking process with six progressive steps: Knowledge, Comprehension, Application, Analysis, Synthesis and Evaluation.

## **STICKING WITH YOUR FUTURE: THE IMPORTANCE OF GRIT**

It is not uncommon to associate a student’s success with intelligence or talent. However, growing research is pointing to a character trait that may separate those who achieve long-term success from those who don’t: grit. Prominent psychologist Angela Duckworth describes grit as a combination of perseverance and passion for fulfilling a long-term goal. Most gritty people have “ferocious determination, are unusually resilient and hardworking, they knew in a very, very deep way what it was they wanted—they had direction.” In Duckworth’s book, *Grit* (2016), this trait was a common factor that enabled students to graduate on time, West Point cadets from dropping out of rigorous military training, salespeople to dust off daily rejections and spelling bee contestants to persevere to the final rounds.

Since the popularization of Duckworth’s research on grit, educators have been all over the topic, asking how they might build it in kids. Little is known on how to build grit in individuals and Duckworth’s only current signal points us to the work of Dr. Carol Dweck on the growth mindset. Dweck’s research shows that intelligence is not fixed but can be developed with hard work, effort and persistence despite setbacks (2006). Grit and related terms such as perseverance, resilience, risk-taking, initiative and motivation, have been identified in some 21st-century learning frameworks. The addition of these intrapersonal skills acknowledge their importance. Together with cognitive and other interpersonal skills, these form the essential set of competencies for the future.

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**6** The Four Cs of 21st-century learning, also known as the Four Cs or 4Cs, are four skills that have been identified by the United States-based Partnership for 21st Century Skills (P21) as the most important skills required for 21st-century education: critical thinking, communication, collaboration, and creativity.



## **4. Game Over: Negative Perceptions, Issues & Challenges**



## Game Over: Negative Perceptions, Issues & Challenges



4.

Since the commercialization of home video game consoles in the 1970s, a myriad of concerns have emerged and some continue to loom large today. One of them is that digital/video games are connected to violence, poor health and addiction, among many others. While this list is by no means exhaustive, it presents an update on the most prominent concerns, as it relates to the adoption of digital games for learning.

### 4.1 The Violence Connection

One of the most highly contested and unsettled issues is the connection of violent video games to real-world violence. Research on this topic abounds and scientists argue that, depending on the research design and framing of the research questions, the outcomes can vary. Ferguson (2013), Slater, Henry, Swaim, & Carder (2004) note, “There is much to learn about the factors that might amplify or attenuate this linkage and about the magnitude of its contribution to violence in society” (as cited in Martins et al., 2013). Similarly, the American Academy of Pediatrics (AAP) Task Force on Violent Media reports, “Violent video game play is linked to increased aggression in players but insufficient evidence exists about whether the link extends to criminal violence or delinquency.” The report also states that there are numerous risk factors for aggressive behaviour and that “violent video game use is one such risk

factor." Additionally, studies among different age groups (17 years and younger; 18 and above) did not offer enough variance to conclude that violence affects a certain age group more than others (2015).

Weigel also confirms the connection but the transference to real-life violence remains inconclusive, "Extensive research has linked violent video games and aggressive behaviour with outcomes moderated only slightly when cultural biases and gender are taken into consideration. At the same time, numerous well-designed studies have found no effect or even a decrease in violent crime in response to violent video games." Weigel also cites that the media always seems to present anecdotal evidence, i.e. "The man who killed 77 people in Norway in 2011 testified that he prepared for the assault by playing the first-person shooter video game Call of Duty: Modern Warfare 2" (2015).

The media indeed play a significant role in influencing public opinion. The aforementioned AAP report says, "News commentators often turn to violent video game use as a potential causal contributor to acts of mass homicide. The media point to perpetrators' gaming habits as either a reason they have chosen to commit their crimes or as a method of training."

To further understand how scientific knowledge has been reflected in the media, a Journal of Communication study (2013) analyzed news reports. It suggests that for about 30 years since the 1980s, "News articles generally suggested that a link between media violence and aggression exists. However, the tone shifted sharply back toward a neutral conclusion since 2000." This change may be attributed to the type of games, the number of unaffiliated sources described and whether the journalist was male or female. The results showed a marked difference in reporting styles between the sexes. "Female reporters were more likely than male reporters to suggest that a link exists between exposure to media violence and subsequent aggression" (Martins et al., 2013).

## 4.2 Screentime: Searching for That Magic Number

As the first organization to publish media guidelines that offer a recommendation for screentime, the American Academy of Pediatrics' (AAP) policy on children and media is widely promoted and referenced by other paediatric associations, parenting and media advocacy groups. It was originally composed in the 1990s when screentime mostly meant watching television or playing early computer games. By 2013, the recommendation had changed to "total entertainment screentime" (including cellphones, tablets and other screen devices) for up to two hours a day for older children, while still discouraging any screentime for children under 2 years old. The AAP recommends, "Television and other entertainment media should be avoided for infants and children under age 2. A child's brain

develops rapidly during these first years, and young children learn best by interacting with people, not screens” (“AAP.org,” n.d.). The recommendations for kids under 2 have not changed but in their 2016 conference, the AAP recommends screentime to be limited to one hour per day for children 2 to 5 years of age. For kids ages 6 and older, “parents can determine the restrictions for time spent using screen, as well as monitor the types of digital media their children use” (Middlebrook, 2016). The AAP explains that their policy must evolve and keep pace with digital innovation, “Case in point, the 2011 AAP policy of statement of media use by children younger than 2 years old was drafted prior to the first generation of iPad and the explosion of apps aimed at young children” (Brown, Shifrin & Hill, 2015).

Upon publishing the AAP’s pending revision of screentime guidelines, The New York Times blog article, “A Reconsideration of Children and Screen Time” (2016) sparked diverse reactions and opinions from readers who self-identify as parents, teachers and physicians. The following is a summary of their comments:

## **1. In agreement with limiting or having no screentime at all**

- A paediatric rehab practitioner shares that increasingly “children are presenting with poor visual motor skills, bilateral skills, muscle strength and finger dexterity needed for successful engagement of school activities.” The practitioner noted that the acts of swiping and poking on light, flat objects do not aid in hand development. Instead, complex movement patterns like playing with toys such as blocks, balls and beads are still what the hand needs. These simple movements, “severely limit the development of sensory integration, force modulation, trunk control, head control, upper body muscle strength, endurance, bilateral skills, prehension patterns and many other skills needed for dressing, holding a pencil, cutting, colouring in the lines, printing and writing, fastening buttons, cutting with a knife, engaging in sports and most other tasks of childhood that can all be affected.”
- Another parent prefers to raise kids without screens and advocates for the use of art supplies and other objects to encourage making, building and experimenting, in addition to having a nurturing time with parents and others.

## **2. Disagree: impractical to limit screens, ban technology, there are benefits**

- A parent shares that screens enable distance learning and that language programs are improving in quality. Cloud storage can make “beloved storybooks” accessible and, in 20 years’ time, the issues and discussion around screentime will be forgotten.
- The “either/or” debate is not helpful, adding feelings of guilt to parents who already have many things to worry about. A parent feels that as long as the child has equal opportunities to play, socialize and exercise, “Exposing them to technology is an important part of ensuring they are ready for the demands of their generation.” Additionally, this parent believes those who don’t use a computer will be stuck with low wage jobs.
- Some parents don’t have issues with screentime and find comfort and assurance using parental control software like Safe Lagoon and Familoop Safeguard.

## **3. Criticism regarding the approach the AAP has taken**

- “The AAP ought to be more scientific than offer simplistic responses to the latest hardware. Instead it might focus on the nature of the content consumed, such as visual or literary typologies on text, audio, video vs interactive, using guidelines based upon DSM (Diagnostic and Statistical Manual of Mental Disorder) categories or more traditional behavioral norms.”
- Another parent points to the immeasurability of screentime’s long-term effects or how to control the countless variables that may affect child development, excluding the “extreme/unrepresentative cases.” The parent argues that the most genuine answer to how much screentime is appropriate for a child can only be, “We don’t know.”

## **4.3 Sedentary Lifestyle**

The Physical Activity and Sedentary Behaviour in Children and Youth Guide from the Canadian Paediatric Society (2015) classifies playing video games as a sedentary activity. Video games have certainly earned that reputation since the inception of home console games where kids are glued captive in front of screens, sitting for hours.

Research linking obesity and video games has also been widely publicized. One such example is that of Canadian and Danish researchers confirming an increase in food consumption among male teens after playing an hour of video games vs. after an hour of rest. In both cases, the teens reported similar ratings for hunger and appetite (Chaput et al., 2011).

In the late 1990s, the popularity of active video game systems or “exergaming” (a portmanteau of “exercise” and “gaming”), opened up a new dimension to what was once perceived a couch-bound activity. The release of exergame titles in platforms like Nintendo Wii (Wii U Fit, Mario Tennis) and Microsoft Kinect (Just Dance, EA Sports Active) enabled the residential market to access games that were previously too large and expensive.

By 2007, activity promoting games like Konami's Dance Dance Revolution (DDR), Gamebikes, and Hopsports have been incorporated into school wellness centres as a way to increase fitness levels to supplement traditional physical activity (Greenberg & Stokes). Games like DDR are widely used in U.S. schools as a regular part of physical education; it has become a weapon to combat the nationwide epidemic of childhood obesity (Schiesel, 2007).

More recently, mobile games like Zombies, Run! (2012), Ingress (2013) and Pokémon GO (2016) are location based, augmented-reality exergames that require players to move, walk or run to play the game. Augmented reality allows players to interact with the game in their real-life setting, for example, in Pokémon GO, Pikachu appears in a real-life sidewalk as seen through the mobile device. A study by Microsoft and Stanford University showed that engaged Pokémon GO users increased their activity by 26% or 1,473 steps a day and, collectively, researchers estimate that the game has “added an estimated 144 billion steps to US physical activity.” The study also noted that Pokémon GO can add to one's life expectancy. Assuming its users continued to play the game, it would add an “estimated 2,825 million years of additional lifetime to its US users” (Althoff, White & Horvitz, 2016).

While exergames can now debunk the perception of digital/video games as purely sedentary activities, the majority of the video games played by kids are still designed as the sitting kind.

## 4.4 Addiction

It's not uncommon to hear a parent struggle with their child's gaming habits. They are learning about the “pull of addiction,” a parent observed that games are designed with consequences if kids don't replay the game often (Section 6.1.5, p. 46). The aforementioned issues regarding kids asking to extend

their screentime is also making parents paranoid. They are quick to refer this attachment as “addiction” when they observe their kids absorbed in gameplay and become irritable when asked to stop. But is it a real behavioural disorder? Video game addiction or, as The American Psychiatric Association (APA) calls it, “Internet Gaming Addiction” (IGD), is not yet included in DSM-5 (Diagnostic and Statistical Manual of Mental Disorder, fifth edition) but has been called out for further study. The top diagnostic criteria include “Repetitive use of Internet-based games, often with other players, that leads to significant issues with functioning” (Sarkis, 2014). In other words, parents need to pay attention when gaming starts to interfere with a child’s quality of life.

### **Diagnostic Criteria for Internet Gaming Disorder** (Sarkis, 2014)

Five of the following criteria must be met within one year:

1. Preoccupation or obsession with Internet games.
2. Withdrawal symptoms when not playing Internet games.
3. A build-up of tolerance—more time needs to be spent playing the games.
4. The person has tried to stop or curb playing Internet games, but has failed to do so.
5. The person has had a loss of interest in other life activities, such as hobbies.
6. A person has had continued overuse of Internet games even with the knowledge of how much they impact a person’s life.
7. The person lied to others about his or her Internet game usage.
8. The person uses Internet games to relieve anxiety or guilt—it’s a way to escape.
9. The person has lost or put at risk an opportunity or relationship because of Internet games.

More than any other video game genre, Massive Multiplayer Online Role Playing Games (MMORPGs) have been closely linked with Internet Gaming Disorder. MMORPGs like World of Warcraft, Age of Conan and Runescape, contain game mechanics that motivate players to play for an extended period of time compared to other games. The levels and achievements are constantly changing and, in higher levels, cooperation with other players is required. This social obligation adds to an already time-consuming game. “If MMORPG participants spend longer amounts of time playing, then they might also experience greater levels of life interference compared with players of other types of video games. An alternative possibility is that players of MMORPGs may to some extent be self-selected in that they may have particular pre-existing characteristics that lead them to favour playing such games. For instance, MMORPG games may seem more attractive to individuals who have sufficient time available to invest in understanding and mastering them” (Kuss, 2013).



The diagnostic criteria of IGD may also be applicable to games offline and on mobile devices. As all forms of gaming continue to be pervasive, perhaps the issue of nomenclature and definitions will be further expanded in the APA's future studies.

## 4.5 Online Safety

With digital/video games increasingly becoming networked and capable of multiplayer modes, playing with total strangers is increasingly the norm. This is still a great concern for some, especially parents with young children who are just learning to navigate the waters of online social interaction. Some games have built-in communication features, such as a chat feature and parents might be surprised to find crass behaviour, bullying, harassment and inappropriate language, not only in comments but in screen names too.

In online digital/video games a bully is called a “griefer”. They don't play by the rules and bring misery to other players. In Minecraft, griefers attempt to destroy creations of other players which may have taken significant hours to build. In the famous MMPORG, World of Warcraft, players complain of being repeatedly harassed through profile impersonations and accusatory behaviour, resulting in some players abandoning the game (Barvinok, 2012).



## **5. Game On: Benefits, Affordances & Advocacy**



## Game On: Benefits, Affordances & Advocacy



As the types, uses and platforms of digital/video games continue to evolve, there is now a plethora of research that suggests there are positive aspects of gaming. From how inherent game design characteristics improve learner engagement—including the rich potential of using digital/video games for learning—to encouraging interpersonal skills like teamwork and cooperation, there is a long list of benefits associated with good-quality digital/video games. To align with the inquiry of this study, the benefits outlined here will focus on digital games' ability to support or enable the learning of 21st-century skills.

### 5.1 Freedom to Fail

In today's ever-changing and competitive workplace, organizations need to accept failure as part of their process if they truly want to innovate. "What we found is that innovation requires a mindset that rejects the fear of failure and replaces that fear of failure with the joy of exploration and experimental learning" (Hess, 2012). Internet entrepreneur and Mint.com founder, Aaron Patzer shares, "Silicon Valley is probably much more accepting of failure than any other place in the world" (as cited in Soppe and McClymonds, 2015). The high failure rate of start-ups has created a *culture of failure*. It's OK to "pivot," an accepted term for knowing when to cut one's losses and steer in another direction. Failures

in high-risk organizations have become en vogue. FailCon founder Cass Philipps shares, “[We’ve] almost come to a fault where we are so proud of our failures here and I wonder if we’re really reflecting on them or just taking a joy in sharing them” (as cited in Soppe & McClymonds, 2015). This suggests that, deep down, failures are still difficult to face.

With real-life applications for the future, children need to learn how to fail—safely. That safe place to practice failure is in playing digital/video games. Gee (2003) cites psychologist Eric Erickson's *psychosocial moratorium*, “Learners can take risks in a space where real-world consequences are lowered.” Players will experience losing many times and rarely has this failure become an obstacle in trying to achieve mastery. “There is something in play that gives players permission to take risks considered outlandish or impossible in real life” (“Instituteofplay.org,” 2015). Salguero (2016), a middle school teacher who uses digital/video games in the classroom, explains “One way to achieve genuine engagement in students is to provide them with the opportunity to experiment with scenarios in which they can examine complex issues and interactions. Games provide a safe and interactive way for kids to engage with complex ideas, put themselves in others’ roles and analyze issues from a perspective different from their own”. Huppert (2016) also explains that digital games have the ability to be customized to a student’s pace with immediate feedback, “The creation of a ‘safe’ place to fail and allowing rapid iterations for learning through simulations that might be too resource-consuming or dangerous if executed in the real world.”

## 5.2 Literacy Launchpad

Digital/video games are vehicles for multimodal literacy. Players take in meaning and knowledge through various modalities, such as images, text, symbols, sound and interactions. Parents share that they believe their kids are learning reading and design, along with sense-making, problem-solving, creativity, logic, planning and organization skills when playing digital games (Section 6.1.5, p. 46). And literacy is not limited to in-game experience. Compelling games successfully engage players enough that players seek the subject matter or its connections outside the game. For example, players may seek out videos on YouTube or Twitch to learn techniques from gaming experts. They will read books such as *Minecraft: The Complete Handbook Collection* to learn how to build complex structures or work electric circuits using red stone. It is not uncommon to hear of Minecraft players become interested in geology or architecture—to the point where kids use Minecraft as a basis for learning 3D modelling and then attempt to learn Sketch-up, a 3D software used in architecture.

Gee (2003) also shares, “In field studies we are conducting at the university of Wisconsin, we have watched 7 year olds play Age of Mythology, read about mythology inside and outside the game on websites, borrow books on mythology and draw pictures and write stories connected to the game and other mythological themes. They think about connections between Age of Mythology and Age of Empires, between mythological figures and popular culture superheroes, and the connections of all to history and society. This is education at its best, and it is happening at home, outside of school.”

## 5.3 Social Learning System

Whether a game is played at home or in school, it can create a reciprocal learning relationship among players of varying skill levels.

### IN-GAME LEARNING

Social learning usually starts within the game itself. Games designed to foster competition, cooperation, communities, tribes and teams are most likely the type of game experiences where players get the highest satisfaction of learning with peers. It can be as simple as players asking for extra lives, a new weapon or a card, or as demanding as working together to support each other in cooperative games like Clash of Clans. The added benefit of multiplayer modes is the ability of the player to invite friends to play along. For pre-adolescent children, playing with friends is a boon to learning.

### EXTENDING LEARNING TO THE GAMING COMMUNITY

Bandura’s Social Learning Theory (1977) suggests that people learn from one another through observation, imitation and modelling, “From observing others, one forms an idea of how new behaviours are performed and, on later occasions, this coded information serves as a guide for action.” When players watch each other’s game play through in-game playbacks, streaming live in Twitch or uploaded tutorials in YouTube, players learn from each other through these modern-day observational mediums. Further, there is reciprocal learning happening in these communities of practice (dedicated forums, blogs and video channels) when players interact with each other trading tips, know-how and game knowledge. Development psychologist, Lev Vygotsky’s theories stress the fundamental role of social interaction in the development of cognition (1978). He believed strongly that community plays a central role in the process of “making meaning.” This may hold true for gaming communities that act as a go-to resource for casual and serious gamers alike. Compelling games typically come with minimal

instructions and players rely on these communities to find knowledge and cultivate relationships under a shared interest.

## LEARNING THROUGH GAMES

This social learning system of games also extends to the classroom. University of Wisconsin game-based learning scholar Constance Steinkuehler noticed, “During in-class gameplay it’s not uncommon to see a student teaching their classmates. Often times students will share skills and guides so that other students can benefit from their experiences. These 21st-century collaborative skills are embedded into the human condition, and games draw these approaches out more frequently and constructively than schoolwork” (2015).

As digital/video games demand players to be active participants, they become invested in the process, willing to share what they know, “Students that are successful in the game can take on a teaching role, which makes them think at a higher level because they have to explain and assist students that might struggle. The game affords students the opportunity to teach each other and in turn, learn better on both the low and high end” (O’Malley et al., 2015).

Huppert also explains that games can be great tools for leadership and teamwork as some require players to assume roles and specific tasks, “Students also developed social and collaborative skills as they elected leaders to fill positions such as production manager, materials manager, siege commander, assistant siege commander, repair technicians and battle recorders. They worked in production teams to negotiate and construct multiple catapults, towers and banners from a shared bin of limited supplies” (2015).



**Figure 2:** The Social Learning System of Games

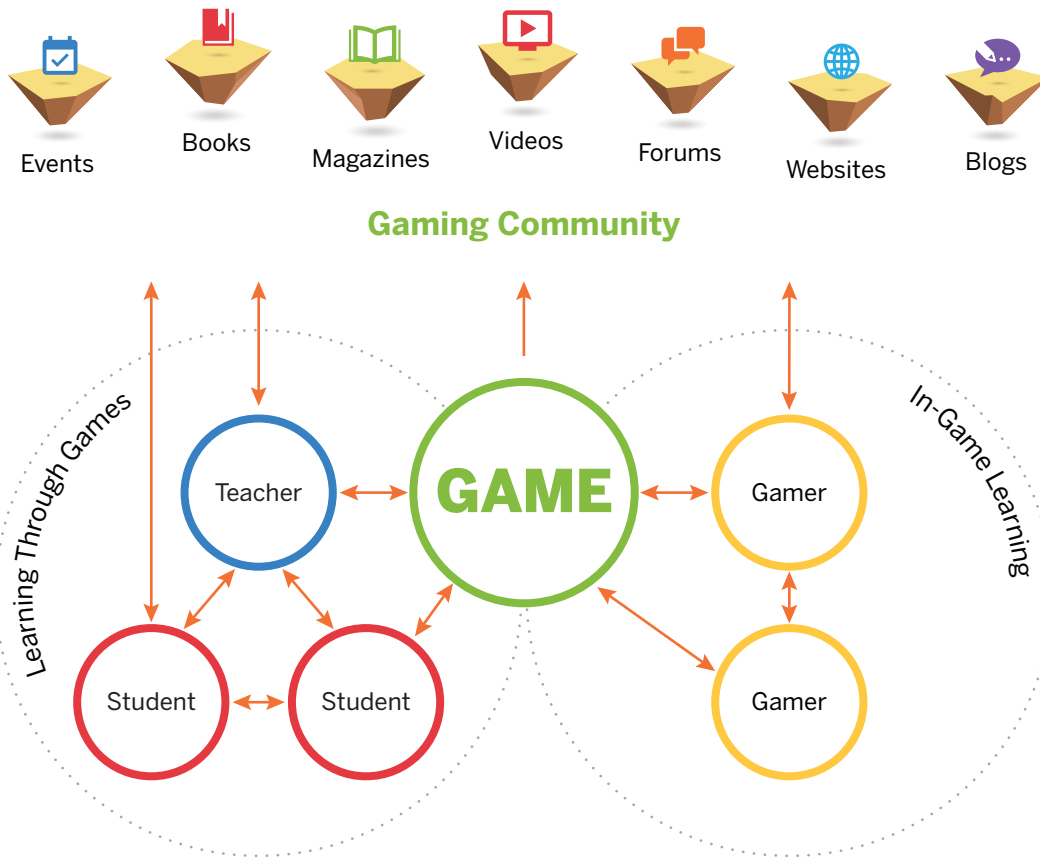


Figure 2 illustrates the reciprocity of learning (of which teaching is also a part) from gamer to gamer, to teachers to students, to student to student and to the larger gaming community. It is a continuous cycle that emanates from one source—the digital game.

## 5.4 Systems Thinking

Defined by systems scientist, Peter Senge (1994), “Systems thinking [is] a way of thinking about, and a language for describing and understanding, the forces and interrelationships that shape the behaviour of systems.” It’s an approach to understanding and solving complex social, technological, economic, environmental, political and, perhaps global, problems. Razzouk argues that systems thinking is a necessary 21st-century skill as it, “Helps learners to think critically and reason logically about problems.

This is important because succeeding in today's world requires that students understand problems and systems, breaking them down into parts, examining relationships among parts, and understanding the behaviour of the parts to come up with informed decisions and appropriate solutions" (n.d.).

Schools that have incorporated systems thinking into their curriculum start with tools and techniques such as behaviour over time graphs (BOTG), causal loops, stocks and flows and, yes, digital/video games. At Quest to Learn, a game-based learning school in New York, students use Gamestar Mechanic, a game application that teaches the principles of game design by letting the student play, design and share their games. "It's built on a strong systems thinking pedagogy. Players progress through a 'quest' in which they acquire sprites with which to build and eventually publish their own games on the Gamestar website. A game designer's vocabulary is introduced; the concept of balancing a game; designing a game concept; and testing and iterating a game. Teachers are informed that 'meaningful play' happens when a player perceives the relation between actions and outcomes in a game and recognizes how those outcomes are integrated into the game system as a whole" (Hall, P., 2013). Because games are systems in and of themselves, built with rules, elements and environments with relationships, they lead to a good understanding of how systems work, allowing learners to visualize the big picture, including concepts of interdependencies, cause and effect, change over time and other connections.

For players who are not enrolled in schools with a systems-thinking curriculum, city and empire builder type games like Civilization, Skylines and SimCity are effective at learning how systems thinking works (Hall, C., 2015). In SimCity, players need to manage their own municipality, minding economic growth through investing in resources, trade and jobs while balancing population and citizen well-being. Decisions such as neglecting to build a park in front of residential areas can cause residents to leave your city; a smaller workforce means fewer tax payers and so on. Imagine the impact of larger issues such as providing electricity, water and employment.

Can players transfer their system thinking skills into a real world system? Some players of Gamestar Mechanic have already demonstrated true understanding by creating examples of political systems and energy systems. Some still think it's just about learning how to create a game; teachers admit there is room for deeper reflection (Hall, P., 2013).





## 6. Online Survey Results



## Online Survey Results



The following data is comprised of results from two online surveys: the parent questionnaire and the learning framework, which were both posted on the companion website to this research, InvisibleTeacher.com. Invitation to participate in the surveys were posted on various websites including the researcher's Facebook community. The data gathered is intended to supplement the literature review, to gain a general pulse on today's parent practices and perceptions on digital games and to gain feedback on the learning framework that was developed.

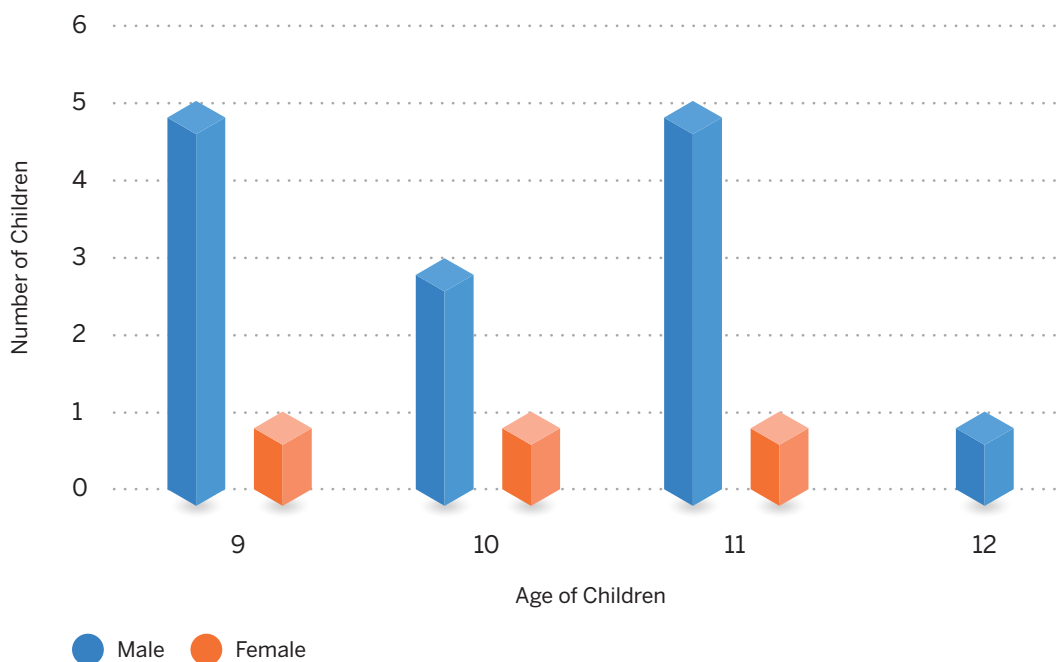
### 6.1 Parent Questionnaire

#### 6.1.1 AGE AND GENDER OF CHILDREN

Figure 3 shows 14 out of 16 parents (87%) who self-elected to answer the questionnaire had children that were male. Further, there is an equal number of boys aged 9 and 11. This data may be important when considering overall parenting practices as they might skew towards parenting boys.



**Figure 3:** Age and Gender of Children

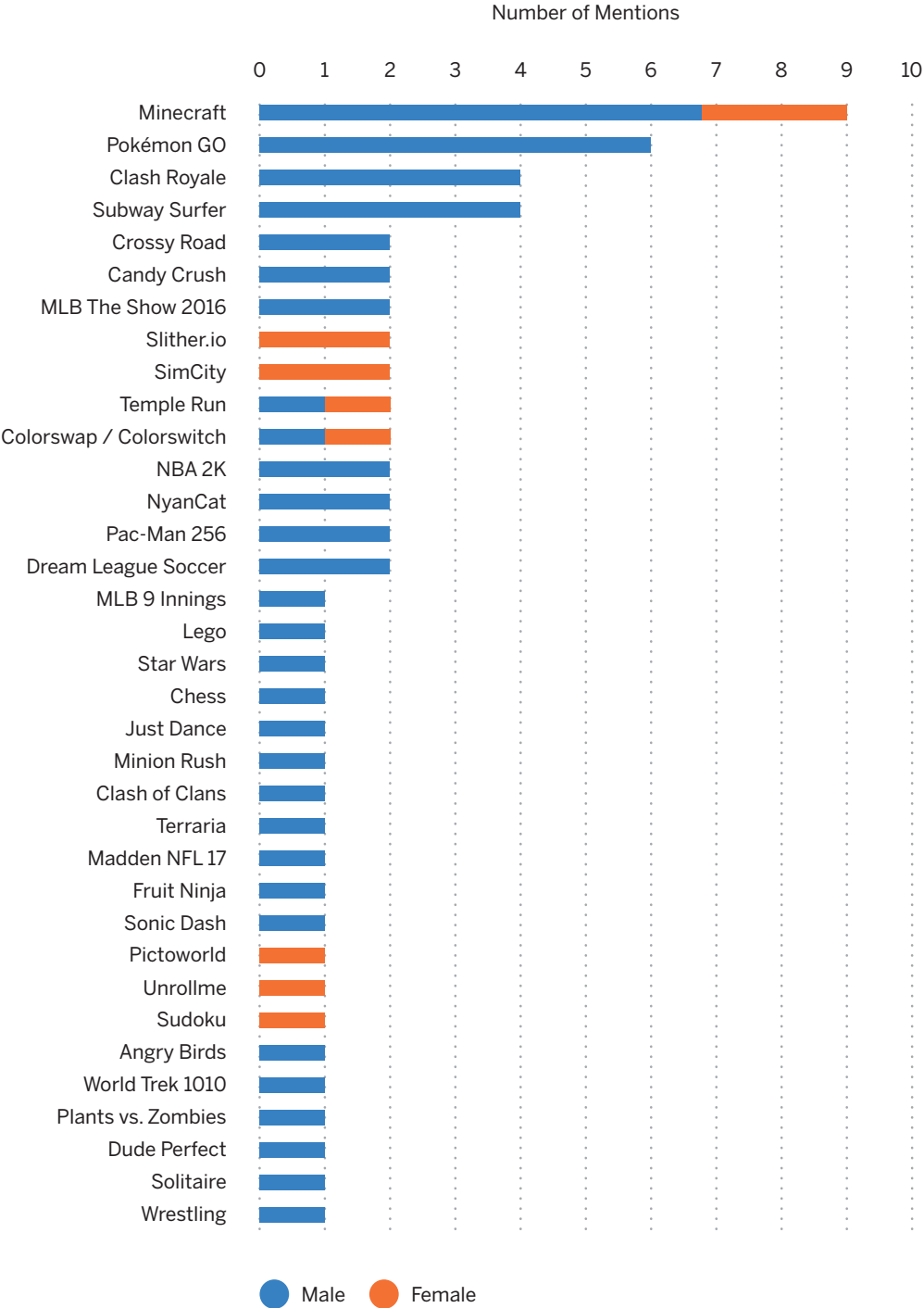


### 6.1.2 DIGITAL GAMES PLAYED BY 9- TO 12-YEAR-OLD CHILDREN

When parents were asked to name at least three digital leisure games that their children play most often on mobile devices, the most popular responses were Minecraft (nine mentions), Pokémon GO (six mentions), Clash Royale (four mentions) and Subway Surfer (four mentions). Eight parents (50%) were able to name three game titles; four (25%) named four to six game titles, and three (18%) named one to two game titles with one parent admitting little knowledge of their child's games. Minecraft, Temple Run and Color Switch are games observed to be played by both genders. Figure 4 charts all the game titles mentioned by the parents of both genders.

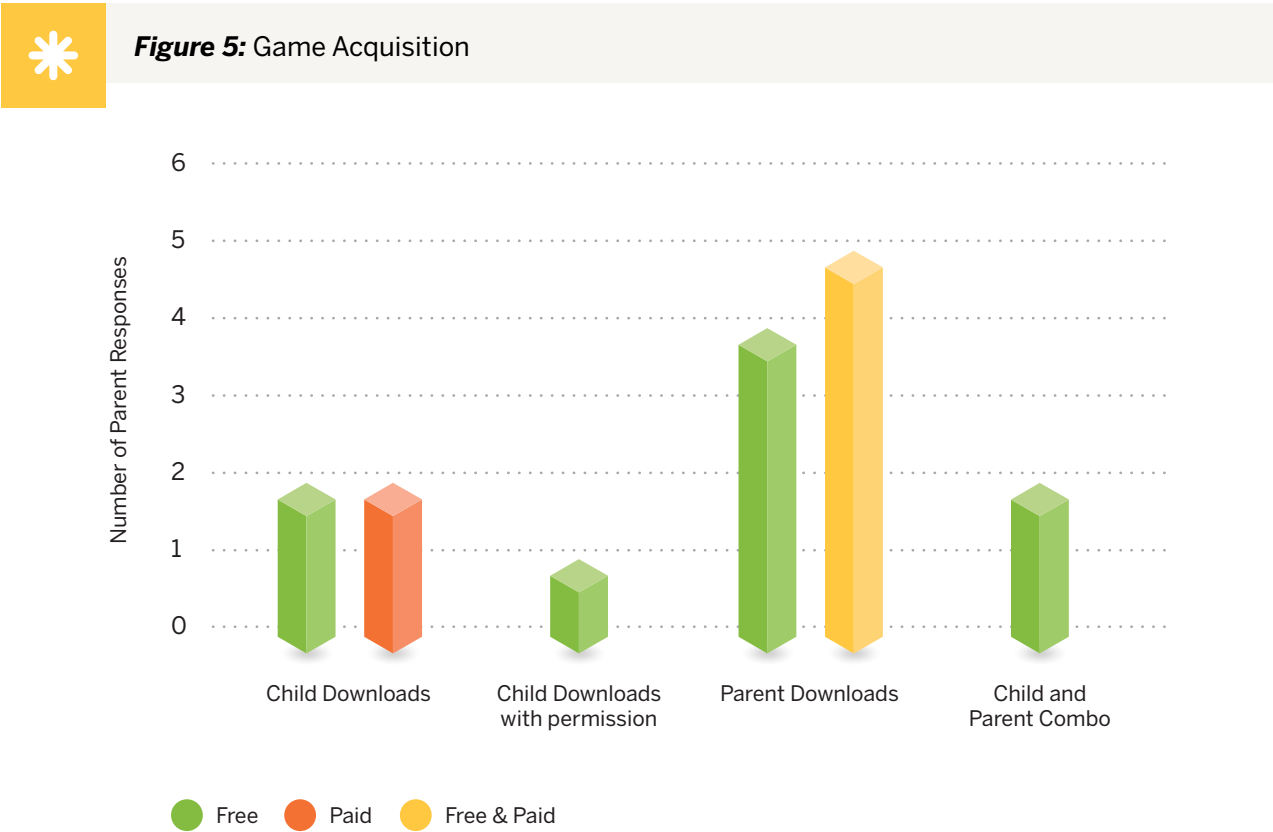


**Figure 4:** Digital Games Played by 9 to 12-year-old children



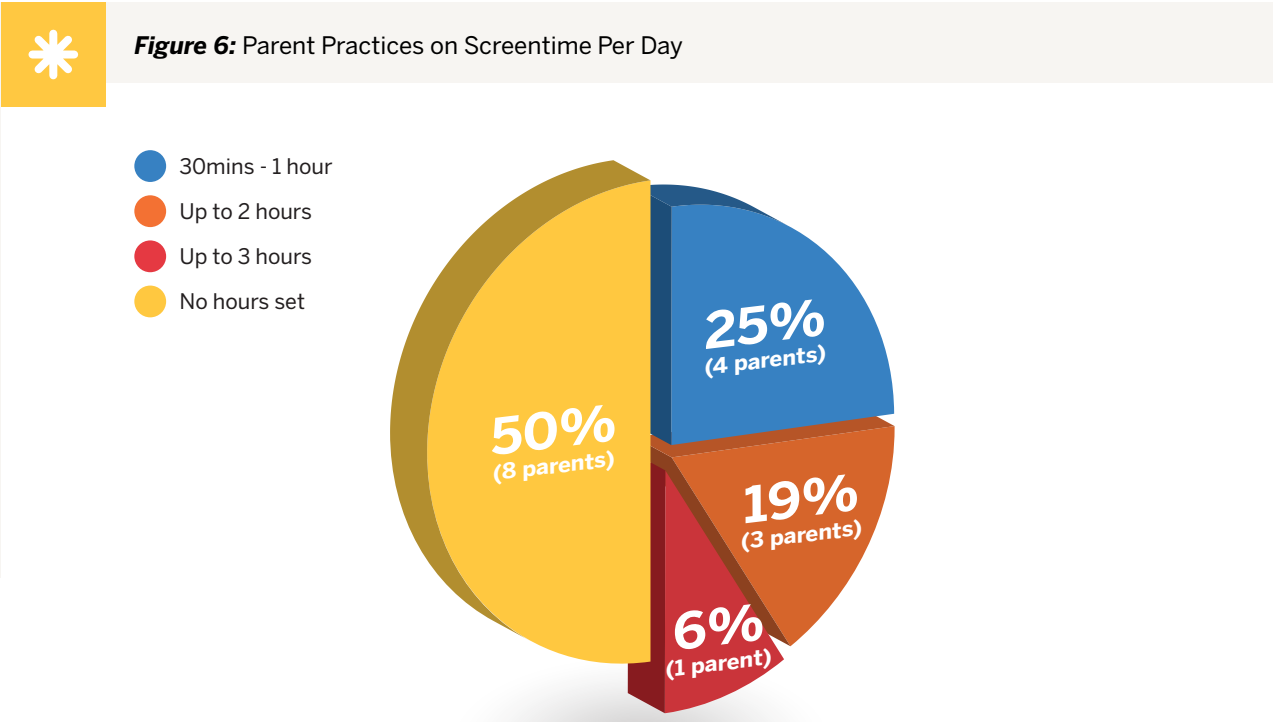
### 6.1.3 GAME ACQUISITION

Nine out of 16 parents (56%) download games for their children and five (55%) of that group download a combination of free and paid games, while four (44%) only download free games. Two parents (12%) share the downloading task with their child, while five parents (31%) admit to having their child download the game by themselves. Of those that allow children to download games themselves, only one does so with permission from parents. The fact that most parents surveyed download free games suggest that they may not appreciate the value of games nor understand the free-to-play business model and its consequences. This is discussed further in section 11.3, p. 108. Figure 5 compares the various game acquisition methods of parents and children.



6.1.4 PARENT SCREENTIME CONDITIONS AND RULES

When parents were asked if they had any conditions or rules regarding screentime as it relates to playing with digital games in general, eight parents (50%) mentioned they do not have any set hours to limit digital gameplay, four parents (25%) allowed 30 minutes to an hour daily, three parents (19%) allowed up to two hours daily and one parent (6%) allowed up to three hours daily.



Parents were almost equally split in their practice of allowing kids to play digital games during weekdays (eight parents/56%) and only during weekends (seven parents/43%). Of those that allowed weekend-only play, six out of seven parents (85%) specified a time limit. Of those that allowed weekday game play, five out of eight parents (62%) did not specify a time limit or said they “casually monitor” their children’s game play. It can be inferred that a correlation exists between weekday gameplay and casual parental mediation. The data also suggests that parents who allow their children to play during weekdays also allow them to play during weekends.

The following digital gameplay conditions and rules were mentioned by parents:

- Parents that allowed gameplay during weekdays mentioned that homework, extra-curricular activities (learning musical instruments, sports) and other priorities (reading time) must be finished before playing digital games. One parent allowed occasional gameplay breaks in between homework.
- Parents also mentioned other rules such as asking permission before downloading, parents must know password at all times, no in-app purchases, sharing with siblings, must play in an open space, timer must be set and no playing during meals. If any infraction occurs, removal of device or losing game-playing time are common consequences.
- One parent who allows digital games on weekends also demands that their child's activities are balanced with outdoor and other non-screen activities.
- Another parent mentioned they need to read reviews before choosing a game for their child to play.

## PARENTING CHALLENGES

The following issues and challenges were shared by parents:

### On Time Limits


- Sometimes, playtime goes over limit if no one monitors; reminders needed
- Excuses to extend playtime ("check something, five more minutes, one more thing, in the middle of something...")
- Negative interactions or mood when asked to stop

### On Rules

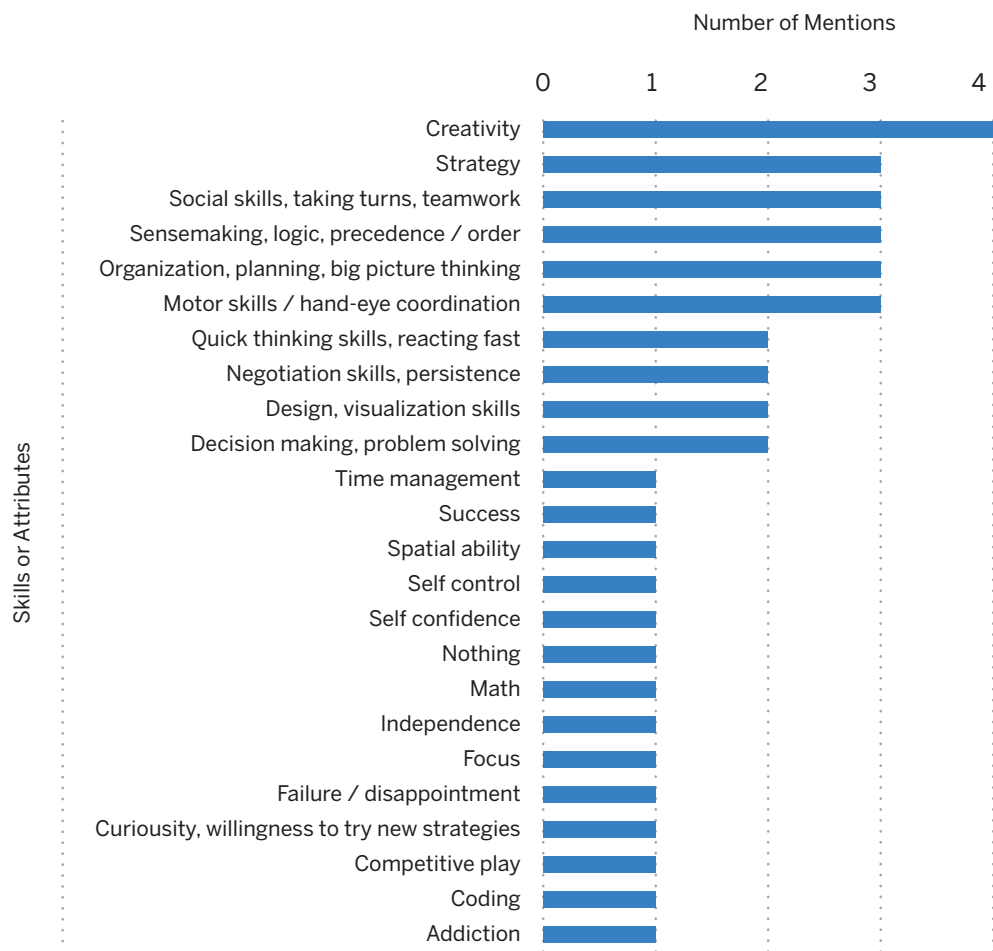
- Rules constantly change, need new ones to cover those not previously thought of
- Parenting styles differ; some more liberal with screentime and causes conflict when child is over at a friend's home for a playdate
- Struggle to implement rules especially when friends play the same game; wants child to socially fit in
- Social pressure among kids to play the same game; child invited friends to Clash Royale clan and it grew from three to 20 overnight
- Easy to maintain rules because family is busy with other activities like sports; kids use their own money if they want to buy in-app purchases
- All devices are monitored using Norton Family; devices are left in the kitchen at night
- Parents impose limited data usage

6.1.5 PERCEIVED SKILLS LEARNED FROM PLAYING DIGITAL LEISURE GAMES

When asked what skills or traits, if any, children are learning when playing digital games, the top responses were creativity (four mentions), strategy (three mentions), social skills, taking turns and teamwork (three mentions), organization, planning and big picture thinking (three mentions) and, fine and gross motor skills (three mentions). Additionally, one parent remarked about learning “nothing” and another mentioned “The pull of addiction.” The majority of the skills mentioned were cognitive, interpersonal and intrapersonal while there were two mentions of content knowledge such as math and coding. This survey question is open-ended and responses were grouped together when the skill or attribute is closely related or a theme is identified. Figure 7 lists all the perceived skills learned from playing digital games as mentioned by parents.



**Figure 7:** Perceived Skills Learned from Playing Digital Leisure Games





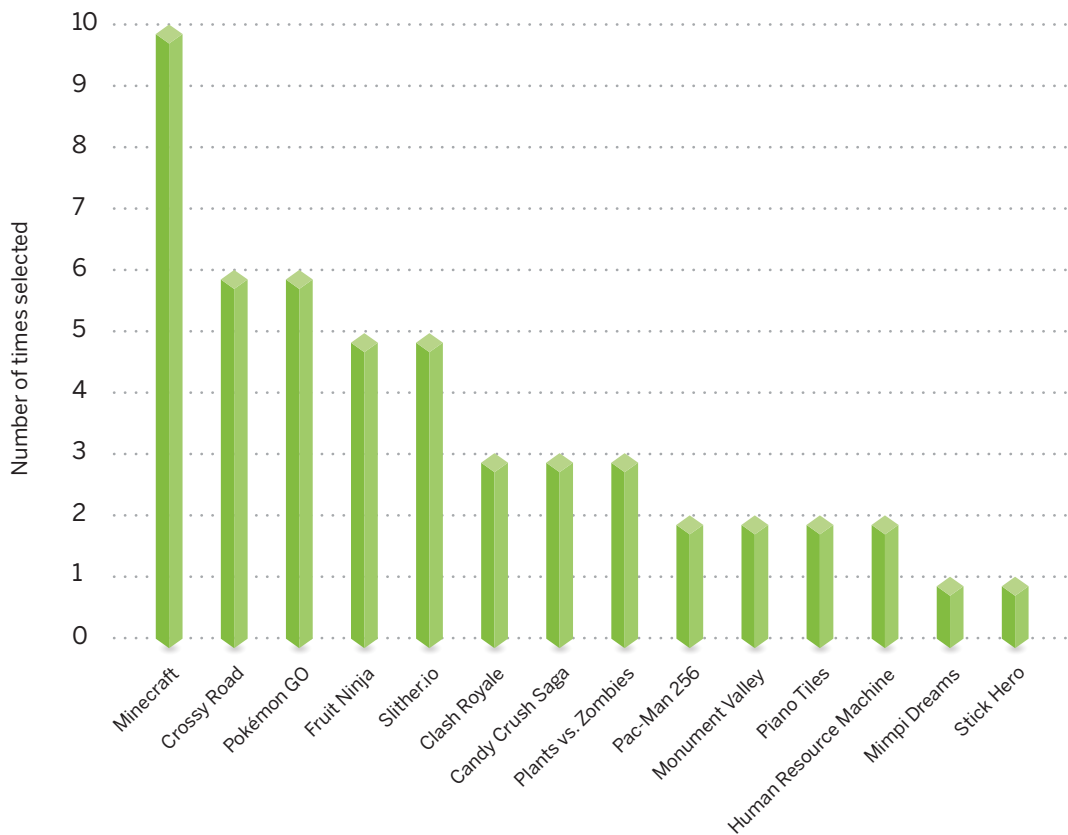
# 6.2 Learning Framework Survey

## 6.2.1 DIGITAL LEISURE GAMES CHOSEN BY PARENTS

When asked which of the 15 digital leisure games they would choose for their child after knowing their critical thinking and grit scores, all parents included Minecraft in their selection, making it the top choice. This is followed by Crossy Road and Pokémon GO, selected six times. Fruit Ninja and Slither.io tied for third, selected five times. Not all top games selected score high in critical thinking and grit. Minecraft scored 100%, Pokémon GO scored 80%. In contrast, Crossy Road scored 26% on critical thinking and grit, while Fruit Ninja scored 33% and 40% respectively. Figure 8 shows the games parents selected after knowing their critical thinking and grit scores.



**Figure 8:** Digital Leisure Games Chosen by Parents



## 6.2.2 PARENT PERCEPTIONS ON THE ABILITY OF DIGITAL LEISURE GAMES TO FOSTER CRITICAL THINKING AND GRIT

When asked if the findings on critical thinking and grit surprised parents: 70% said they were surprised; 30% said they were not surprised.

### **Comments of those surprised mentioned:**

- Games that “drove me crazy” (e.g. Clash Royale) score high on both critical thinking and grit. Parent wants to understand such games better so they can see the benefit for their children.
- Never occurred to a parent that these games have positive impact on well-being so they are surprised to learn there’s value in them.
- Does not know any of the games well but feels this framework verifies that games have more value than pure fun and entertainment.
- Expects games to be for play; no expectation of learning “serious skills” but acknowledges that real world playing can teach skills like cooperation and presupposes that digital games might do the same.

### **Comments of those not surprised mentioned:**

- Long suspected that games have built-in features that allow children to extend their thinking skills. Minecraft loved by son, allows him to practice creativity.

## 6.2.3 IMPORTANT FACTORS

On a scale of 1–5, with one being the most important, parents were asked to rank the most important factors in choosing a game for their child. Table 2 shows the ranking of the factors.

**Table 2:** Factors Important to Parents

Factors	Rank	Score
Age-Appropriate Content	1	1.6
Teaches 21st-Century Skills	2	2.3
Positive Character Traits	3	2.3
Fun, Entertaining, Free	4	3.7
Teaches Academic Content	5	4.8

These scores are averaged based on all the responses. Age-appropriate content was the unanimous choice for the top consideration. Teaches 21st-Century Skills and Positive Character Traits scores are tied for second, which suggests that parents may value them equally. Interestingly, Teaches Academic Content ranks last which may suggest that these parents are not likely to consider digital leisure games as a medium in classroom instruction.

**6.2.4 FEEDBACK ON THE LEARNING FRAMEWORK**

When parents were asked about the value and usefulness of the learning framework, the feedback was generally positive with suggestions on ease of use and deliverability. The following responses were collected:

*“Fantastic, turn into an app or interactive guide so easier to use/read.” Still thinks parents need to oversee playing and maybe play themselves once in a while to know what kids are really learning.*

*“Yes, will use this information when selecting games for children.”*

*“Yes, will use but needs to be summarized in a shorter, informative manner. Most parents don’t have time to go through all the details.”*

*“Yes will use, but might be too difficult to use for each game, perhaps when it is used as a way to decide on which games to purchase. I can see a future where there is a labelling system similar to foods so consumers can be guided to choose the good ones from the bad ones.”*

*“Yes, I think this is a valuable guide, would be great to see this beside app ratings so we can look at games together and assess the benefit of the game before we download it.”*

*“I’m interested in the learning framework but not sure if I would seek it out as my kids are 10 and 13 and I am not too involved in the games they play and neither are they really into it (they already know that violent games or age inappropriate games are not okay in our house). I can definitely see how this would be an excellent tool for helping manage gameplay of kids who are really into them.”*

*“Very interesting and something worth looking more into. Maybe see if the framework can be used for other skills? It just needs to be easier to read or use like a quick stamp or a rating guide.”*

## 6.3 Limitations

### 6.3.1 LIMITED DATA & CLARIFICATION

The online survey was chosen for busy parents because it is a flexible method, allowing them to respond at their convenience. Participants were guaranteed anonymity and confidentiality so they could freely respond without judgement. Further, the form fields were not mandatory so they could choose to answer questions they are comfortable with.

This design has some limitations. There are some instances in which the responses did not have any supporting explanation and the researcher may have missed relevant supporting information to capture new trends or meaningful relationships. For example, only one explanation was recorded from a parent who was not surprised by the game reviews on critical thinking and grit; the rest of the participants left it blank. While most parents who were surprised explained their position, it would have been insightful to also understand why other parents were not surprised at all.

The nature of online questionnaires prohibits further probing when a participant has responded with provoking or unclear answers. The participant’s understanding of words and questions may have

caused them to interpret questions differently, especially on open ended questions. Further, the use of online recruitment does not guarantee a number of responses. This study received a small sample size from which themes and conclusions were drawn. A future opportunity exists to capture more data and revisit how conclusions may or may not have changed as a result.

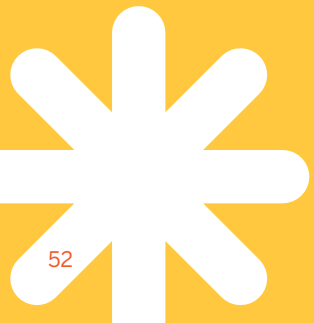
### **6.3.2 ONLINE RECRUITMENT & SELF-REPORTED DATA**

Recruiting participants via social media and Internet was challenging. Though efforts were made to find websites that were diverse and an audience that was closely targeted to the participant profile desired, the nature of online questionnaires is such that participant identities may not be verified. Although data received suggested that participants were parents with digital game-playing children as their responses were congruent and not wildly out of line with literature research, the researcher has no ability to track which websites the responses came from. Further, the researcher's Facebook community was one of the sources of online recruitment and while "friends" were not explicitly tagged to respond to the questionnaire, the sample that responded may have some bias such as similarity in nationality, parenting viewpoints and perhaps the desire to project themselves as good parents should the researcher clue in to their identity. The researcher, however, was not able to correlate the responses to any specific parent.

Future research may explore recruitment through a neutral third party so participant profiles are verified and any potential bias can be avoided. Recruitment need not be limited to online sources and can include parent groups or associations, libraries that have gaming programs and schools to ensure a diverse and larger sample size.



## 7. The Learning Framework



# The Learning Framework



## 7.1 The Process

To identify whether skills such as critical thinking and grit can be fostered in the context of digital leisure games, there was a need for a comprehensive set of criteria from which each game could be equally assessed—a framework was needed. During the auto-ethnography stage (Section 2.2, p. 8), the researcher noted all possible game design elements (rules, goals, challenges, etc.) that existed in each game. These game design elements were matched with the definitions of critical thinking and grit. As game design elements come in varied forms, this was a highly iterative process of clustering to find similarities and differences. Eventually, different levels emerged. The levels ensured that the game design element is grouped within its category (i.e., game mode) while acknowledging differences in execution, as this affects how much skill can be fostered in the game. To ensure that a comprehensive set of game design elements were covered, a diverse assortment of genres commonly played by 9-to 12- year-old children was one of the criteria determined in choosing digital games. The learning framework created is further explained using the following steps:

## STEP 1: DEFINITION OF SKILL

The framework begins by defining skills, e.g. Figure 9, “Does the game allow the player to...” includes the first definition of critical thinking, ‘Build knowledge’. The definition is further broken down into parts, including sub-definitions and examples. The sub-definitions are chosen for the way they relate to the skills used in the game. In Figure 9, the ability to “Build knowledge” in the game context involves identifying or recognizing the purpose of the game, what problem the player is asked to solve and what the goals are. In doing so, the player may be able to raise questions about the goal; this is critical thinking.



**Figure 9:** Sample of Critical Thinking Definition and Sub-definition

**Does the game allow the player to...**



**Build Knowledge**



Identify/recognize purpose, problems, goals, the main task; raise questions about the goal.



## STEP 2: ALIGNING SKILL DEFINITION WITH GAME DESIGN ELEMENTS

After creating skill definitions, the game design elements (GDE) encountered in the 15 digital leisure games reviewed (Section 2.2, p. 8) were aligned to each skill. The definition of GDE may include:

- Game mechanics – Actions or methods of interaction such as jumping, running, flying, casting spells, using weapons, capturing objects, etc.
- Rules – What players are allowed or not allowed to do and if there are constraints like time or number of lives, including how rules are conveyed, i.e. whether they are explicit, implicit or emergent.
- Goals – The objectives of the game, also known as *victory condition mechanics*. It can be one or many goals. It can take the forms of points, loss avoidance, territory control, a quest, structure building or a combination of many conditions.
- Difficulty level – The challenges and how it scales as players' skills improve.
- World – The environment in which the game is played and whether it limits the players' movement and choices or if it exists in a truly open space where the players are allowed to create elements that shape their world.
- Mode – Whether a game is played solo, with another player (player vs. player), with many players (multiplayer) or the game (artificial intelligence). Also, whether it's online or offline and the pace and competitiveness of gameplay (Zen, tournament, arcade, etc.).
- Atmosphere – Whether there is supporting narrative, graphics, sounds, speed that affect the general gameplay experience.

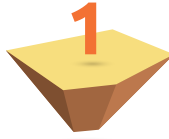
Completing the question, “*Does the game design have...*” with specific game design elements demonstrates how specific skills are being tapped in the game.

The example in figure 10 shows that knowledge is built by identifying game goals and tasks through an instruction or guide.



**Figure 10:** Sample of How Skill Definition Aligns with Game Design Elements

**Does the game allow the player to...**



**Build Knowledge**



Identify/recognize purpose, problems, goals, the main task; raise questions about the goal.



**Does the game design have...**



Instruction/guides

### STEP 3: ASSIGNING LEVELS

Further to assigning GDE to the skill definition, the framework also takes into account that some GDE have varying degrees of skill association. Building on the previous example, game instructions or guides demonstrate the game is helping the player *Build Knowledge*; however, in some games, instructions are not explicit and there is little overt telling. As such, the player is forced to use more of their critical thinking skills to understand how the game is played. Further, some games do not have any instructions at all—the gameplay is absolutely emergent and requires the player to use the highest order of thinking skills to participate. The preceding examples describe the three varying levels in which the GDE can be

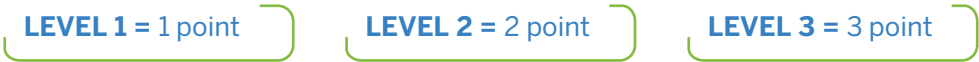
assigned. Level one shows the lowest, level two is moderate and level three shows the highest degree of skill required required.

Figure 11 illustrates the three levels of game design elements aligned to the definition of being able to build knowledge within the game.



STEP 4: SCORING

Levels determine the degree to which a skill may be fostered and are assigned a point value to help calculate scores. Level 1, which requires the lowest use of skill, is assigned one point. Level 2, which requires moderate use of skill, is assigned two points and Level 3, which requires the highest use of skill, is assigned three points.

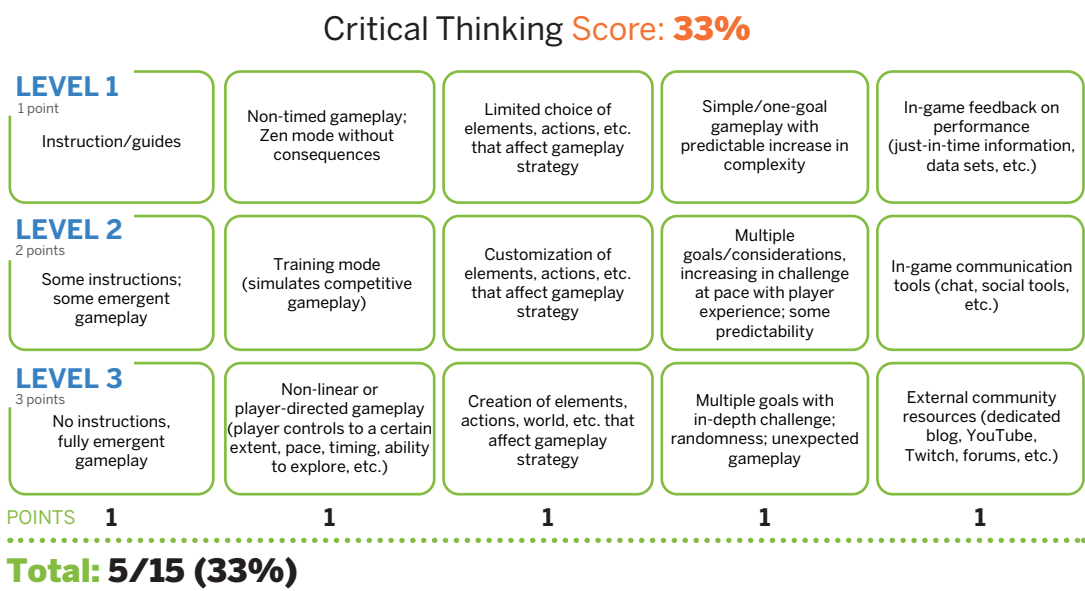


The total scores for each game were tallied out of a 15-point maximum and then converted to a percentage (100%). The following marks are a general guide when reviewing scores:

- Games that score 0–5 out of 15 points or 0–35%: Low skill requirement
- Games that score 6–10 out of 15 points or 36–70%: Moderate use of skill
- Games that score 11–15 out of 15 points or 71% and above: High use of skill

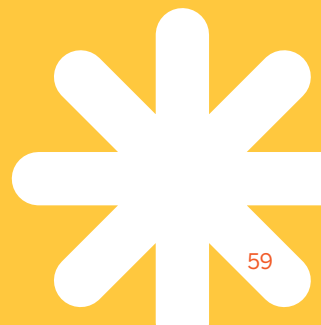
Figure 12 provides an example of a digital game in which the critical thinking scores are consistently at level one. The total score is 5/15 or 33% which presents a low critical thinking score.

Figure 12: Sample Scoring





## 8. The Critical Thinking Learning Framework



## The Critical Thinking Learning Framework



According to Reichenbach (2002), critical thinking is a group of interconnected skills that allows one to analyze, creatively integrate and evaluate information. Reichenbach defines it as a thinking process with six progressive steps: Knowledge, Comprehension, Application, Analysis, Synthesis and Evaluation.

In our daily lives, we may perform these skills individually, in successive order, experiencing distinct phases of critical thinking. In the context of games, the use of these skills is usually concurrent and cyclical; the player is largely unaware of the multiple mental processes occurring during gameplay. For example, a new player in the tower defense game, Clash Royale will start out in the Training Arena. The player is introduced to the goal: to demolish more towers than the opponent by using battle troop cards (knowledge and comprehension). With a limited hand, the player is asked to select the cards to be used for battle (application). The battle begins and the player deploys each of their cards to defend, attack or do both with a time limit (comprehension, application, analysis, knowledge). This cycle of defence and offense is repeated several times until time runs out. The process of comprehension, application, analysis and knowledge is repeated. Whether the game is won or lost, the player is able to reflect on the gameplay and recreate a new card deck and strategy for the next battle (synthesis, evaluation and reflection). Other game genres may not follow this exact model, however, the concept of having multiple processing skills happening simultaneously is common.

Given the context of how critical thinking happens in games and in the interest of clarity, the definitions are selected based on the dominant critical thinking definition and the game design elements that best support it. Figure 13 illustrates the three definition clusters of critical thinking and its corresponding sub-definitions.



## 8.1 Build Knowledge

As mentioned in the framework process examples (Section 7.1, Figure 11, p. 57), the first step in critical thinking is *knowledge*. Within the game, players gather knowledge when they identify or recognize purpose, problems, goals or the main task. The game design element that aligns with this definition is the presence of instructions or guides, whether they are explicitly shared step-by-step, in static screens or through guided demonstrations (level 1). They may also be revealed over time, usually introduced as levels become more challenging, also known as “just-in-time information”(level 2). Or, there may be no

instructions at all requiring the player to build knowledge through emergent gameplay. In this case, it might be an iterative cycle of observation, comprehension, analysis, application and evaluation—as if going through a mini critical thinking cycle within this knowledge-building stage (level 3).

## 8.2 Build Comprehension, Analysis and Synthesis

The next three critical thinking steps are grouped together, as most of the game design elements allow for these skills to happen simultaneously or in close order.

1. To build *comprehension*, the GDE must allow the player to understand relevant information, discern how elements are organized and interpret meaning or significance. This comprehension should allow the player to construct assumptions, inferences and recognize values and concepts.
2. To promote *analysis*, the GDE must allow the player to break into parts, make clear how ideas and elements are ordered, related or connected to other ideas or parts. The player must be able to differentiate, classify or categorize elements, actions or ideas to understand gameplay order and priorities.
3. To enable *synthesis*, the GDE must allow the player to predict/infer from actions or elements and add, combine, customize, rearrange or create/design their own ideas, elements, actions or solutions.
4. *Application* is the use of facts, rules and principles gathered from *knowledge* and *comprehension*. As games are an active, hands-on experience, game playing is *application* itself. For that reason, this step in the critical thinking process is not singled out; instead, it's assumed to be a constant for this medium.

The GDE that align with *comprehension, analysis and synthesis definitions* are classified into the following:

### A. Game Modes

Digital games come in one or several modes. A mode is a version of the game that has a distinct configuration so the settings presented are different each time. The type of mode chosen varies the gameplay experience. Some mode examples include *Zen* (usually configured to be played without consequences such as obstacles or loss of “lives,” *Multiplayer* (configured to allow one or more players to compete with each other in real time) and *Arcade* (usually a fun variation where quick reflexes are



tested but rules and conditions significantly vary depending on the type of game). In Fruit Ninja, the *Arcade* mode allows players to swipe as many fruits within 60 seconds while avoiding bombs. In Piano Tiles, the *Arcade* mode makes the screen scroll automatically and players have to hit the black keys before they disappear off the bottom.

Modes are one way the player can increase the game's level of difficulty and challenge. Modes may also refer to the general gameplay design whether it is linear or non-linear. Linear games will typically have pre-defined goals and the progression of challenges are fairly predictable. Every player navigates the game within the confines of the game rules and experiences the same challenges in the same order. In non-linear gameplay, sometimes referred to as "open" or "sandbox" mode, gameplay is emergent. Players are allowed to create their own solutions, explore multiple routes to finish the game or have optional side-quests or subplots. Every player may have a unique game experience depending on the choices they make.

In the context of fostering critical thinking, games that come in modes that lower the challenge, or show explicit information for easier game play, require less critical thinking from the player as the level of comprehension and analysis may not need to be as extensive. In contrast, games that are fully emergent and more challenging require players to invest more time, more active comprehension and more analysis to achieve success.

Here are the following mode levels:

- **Level 1** (Low Critical Thinking): Games that have modes where the challenge is lower usually have few constraints, such as non-timed gameplay, unlimited number of "lives" or playing without consequences.
- **Level 2** (Moderate Critical Thinking): Games that have a training mode, such as the training camp in Clash Royale or the artificial intelligence (AI) mode in Slither.io, allow players to play the game in a simulated environment to practice their skills before engaging in competitive play. The challenge is the same as the actual game without the consequences.
- **Level 3** (High Critical Thinking): Games that have a non-linear mode do not force the player to move along a certain path or direction. Instead, they allow the players to be self-directed, control the pace and offer the option to explore the game environment.

Figure 14 illustrates the three levels of game modes that align with building comprehension, analysis and synthesis.



## B. Levels of Customization

Games allow their players to contribute to their own success in varying degrees. Some games give players choices with pre-determined rules and conditions. Some games allow their players to customize settings and, to a certain extent, offer elements that may affect game strategies. Other games give almost full control to their players, allowing them to co-create the game world. These varying degrees of player participation affect the overall gameplay and how much critical thinking is required of players.

Here are the following levels of customization:

- **Level 1** (Low Critical Thinking): Limited choice of elements or actions that affect gameplay.

Games that have set rules will introduce variety and challenge to gameplay by allowing the player to choose certain elements such as an avatar (Runner for Crossy Road), boosters (Colour Bomb in Candy Crush) or type of weapon (Flame Blade in Fruit Ninja). These elements may affect gameplay by increasing the player's ability to score faster, higher and easier. These rank low in critical thinking because the elements presented are usually obvious in value. The player does not require critical analysis to determine if these elements will improve their gameplay; the game almost always already suggests it. Set game rules also limit the player's analytical thinking, showing only what is available, not what is possible. It voids their ability to synthesize and create new solutions.

- **Level 2** (Moderate Critical Thinking): Customization of elements or actions that affect gameplay.

In Plants vs. Zombies, players choose a combination of plants with varying strengths to ward off zombies. The player is limited to choosing five plants for each round. As such, the player needs to combine a strategic set of plants in anticipation of the types of zombies that will attack. Another example of customization is when the player chooses one or combines several Pokémon to battle a controlling Pokémon. In both cases, the player uses their comprehension and analysis of the plants or Pokémon's characteristics (strengths, function, health, speed, etc.) and synthesis to combine a strategic group to win. Such games provide more opportunities for critical thinking beyond available choices.

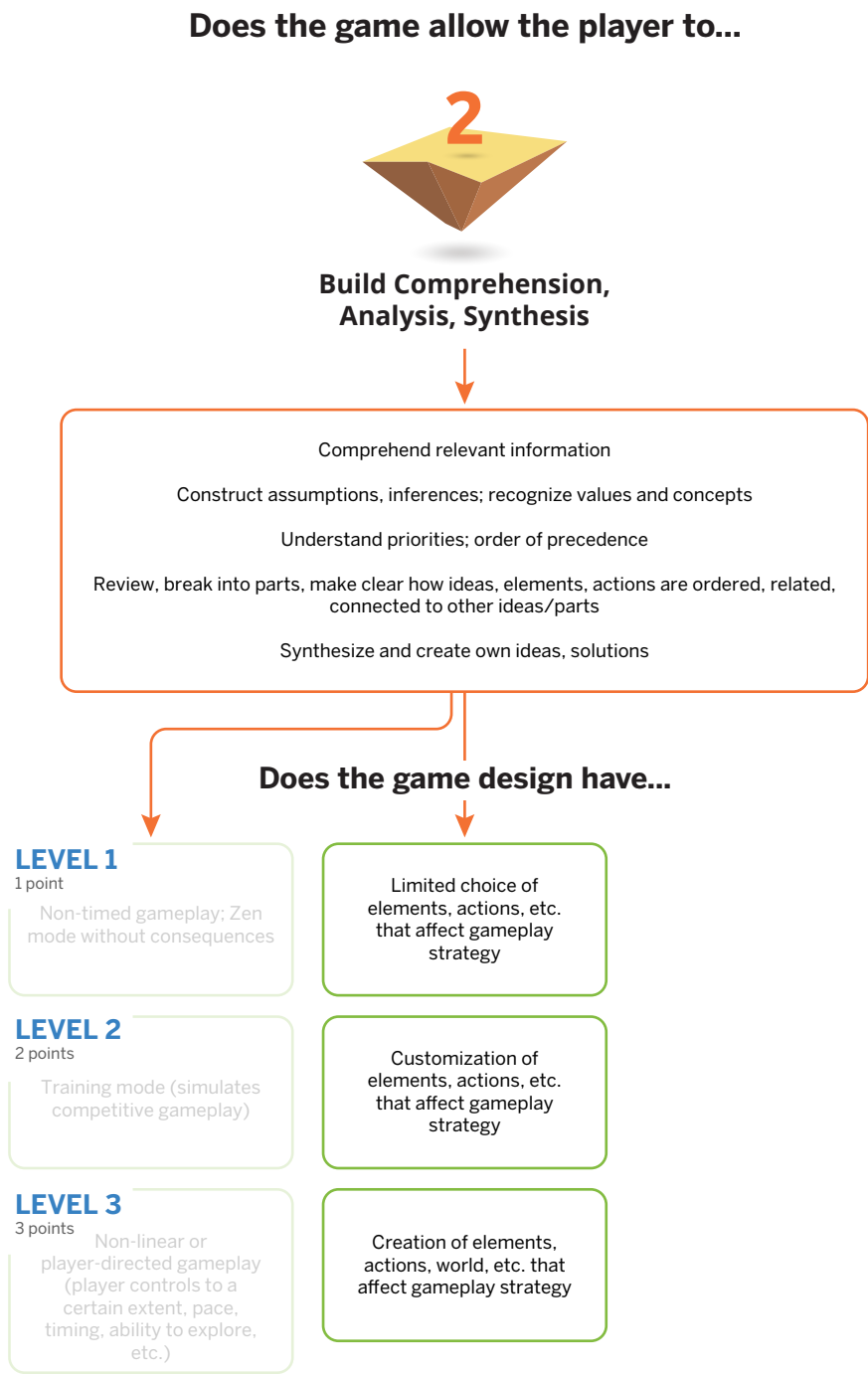
- **Level 3** (High Critical Thinking): Creation of elements, actions or worlds that affect gameplay.

When the player is allowed to create game elements and actions, the requirement to comprehend and analyze the game environment to be successful is imperative. The player is free to synthesize any of the elements, actions or information gathered. In Minecraft, for example, the player is dropped randomly in a biome or terrain. They must explore the space in order to understand what to mine, build and how to defend themselves to survive. The game requires that players mine available resources, which can then be fashioned into tools and shelter. A simulated day and night cycle adds to the urgency to find these resources to survive the night. Through experience, the player comprehends and analyzes the game world they are in and, through trial and error or defeat from zombies, the player can synthesize all knowledge gathered to prepare for the next day.

Figure 15 illustrates the three levels of customization that align with building comprehension, analysis and synthesis.



**Figure 15:** Critical Thinking Framework Game Customization Levels



## C. Goals

Closely related to challenges are goals. Critical thinking can be fostered depending on the type of game goals. Some games have a single goal (to cross the road for as long as you can in Crossy Road); some games have multiple goals (first capture Pokémon, then gather resources in Pokéstops, then accumulate enough experience to battle in gyms at Pokémon GO). Other games have multiple goals with a degree of randomness or unexpected gameplay (defend and attack towers simultaneously depending on opponent's weapons and battle cards in Clash Royale). Typically, the challenge also scales as the goals increase or become more complex. As such, critical thinking is required in most games with multiple or complex goals where challenges are random and unexpected.

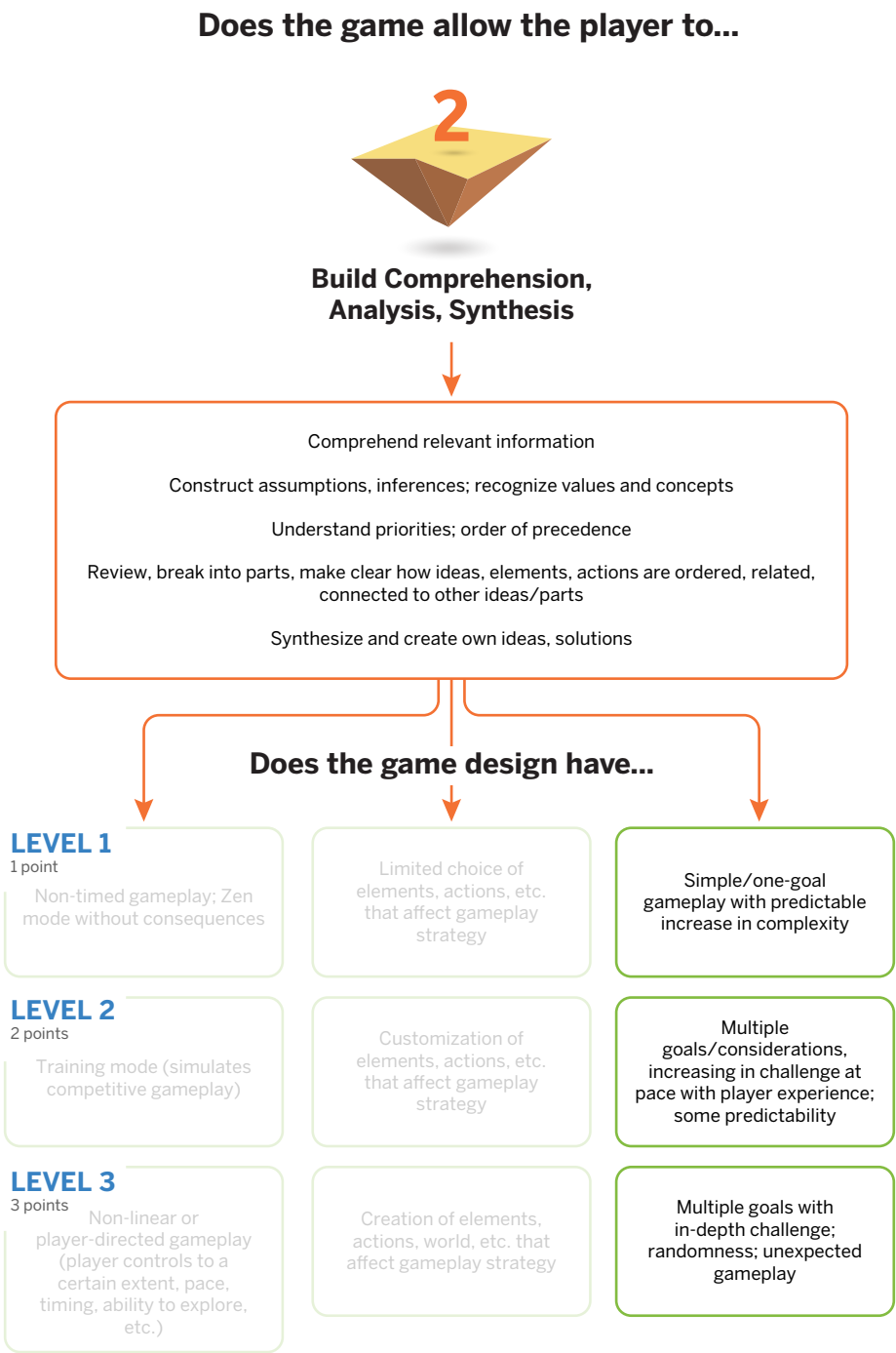
Here are the following goal levels:

- **Level 1** (Low Critical Thinking): Simple, one-goal gameplay with predictable increase in complexity.
- **Level 2** (Moderate Critical Thinking): Multiple goals/considerations increasing in challenge parallel with player experience; some predictability.
- **Level 3** (High Critical Thinking): Multiple goals with in-depth challenge, randomness, unexpected gameplay.

Figure 16 illustrates the three levels of game goals that align with building comprehension, analysis and synthesis.



**Figure 16:** Critical Thinking Framework Game Goal Levels



## 8.3 Evaluate

The last step in the critical thinking process is evaluation; that is, arrive and test, assess conclusions, solutions, assumptions or actions. Every time the player takes a turn or replays the game, there is an opportunity for evaluation. Games are designed with feedback mechanisms that allow players to know how they are doing (scores), what is allowed or not allowed (physical barriers such as bumping into walls), what mechanic or gameplay element might be coming up (splash screen with a narrative), what information has been gathered (data sets) and other graphical or auditory signals that allow the player to assess their own performance.

- **Level 1** (Low Critical Thinking): In-game feedback (just-in-time or on-demand information, data sets, etc.) is explicit and generally pushed to the player or easily accessible within the game. For example, the chart in Cooking Fever shows the player how many customers have been served, how many are left, how much food equipment has been upgraded, what level the player is on and what rewards are available. Pokémon GO has a data set in the form of a Pokédex, which allows the player to reference the different types of Pokémons they have captured, along with their basic statistics.
- **Level 2** (Moderate Critical Thinking): In-game communication (chat, social tools) may be available but requires the player to take the initiative to use them. An example is the chat feature in Clash Royale which allows players to ask other clan members to donate cards they need or to engage in “friendly-battle” as a way to practice combat.
- **Level 3** (High Critical Thinking): External Community Resources (dedicated blog, YouTube, Twitch, forums, etc.). At this level, players go outside the game and seek game communities to further understand and improve gameplay.



Figure 17 illustrates the three levels of feedback that align with evaluation and reflection.



**Figure 17:** Game Design Elements That Demonstrate Evaluation and Reflection

**Does the game allow the player to...**



**Evaluate (& Reflect)**



Arrive & test, assess one's conclusions, solutions, assumptions, actions  
Think openly with alternative thoughts

**Does the game design have...**

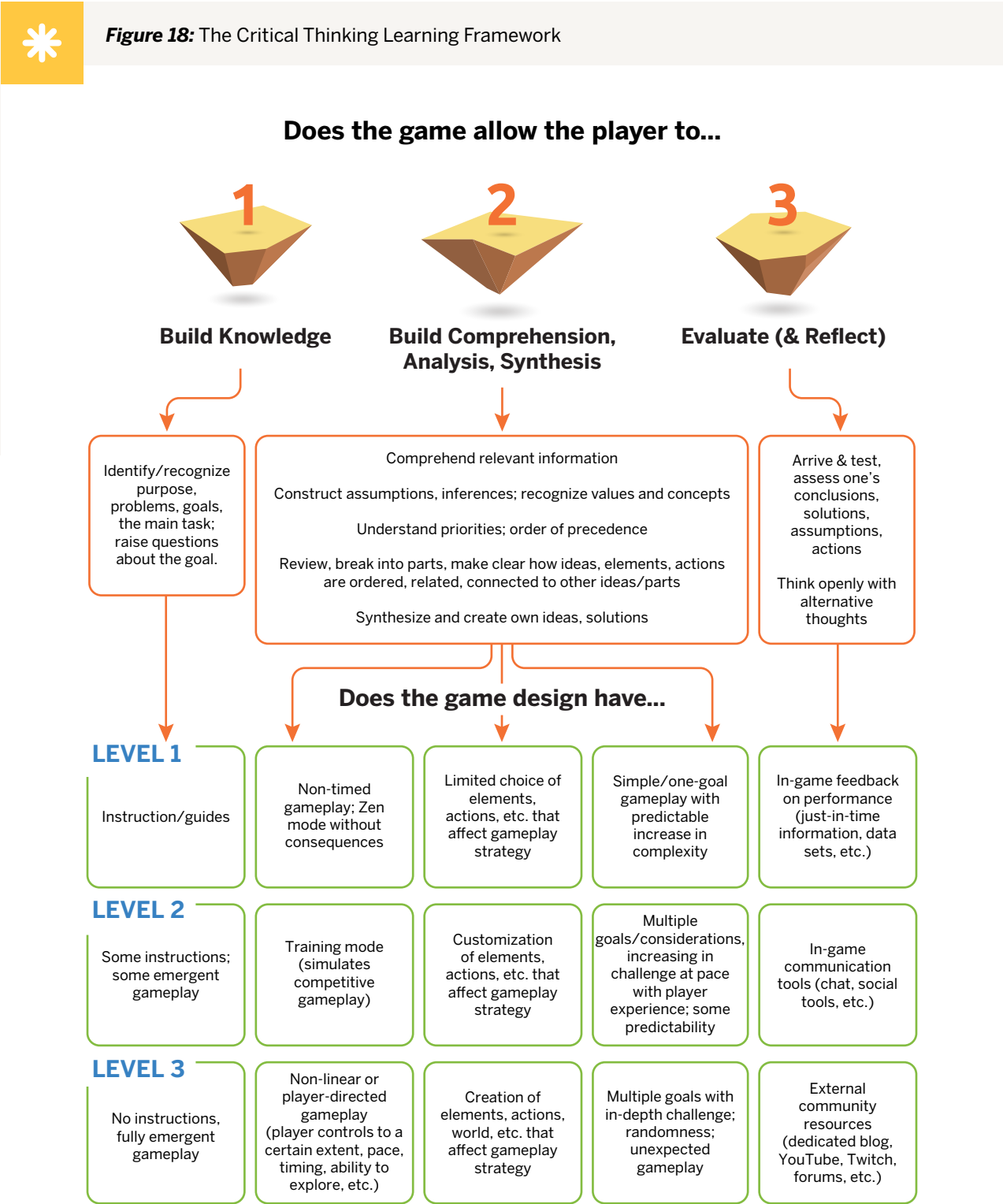


In-game feedback on performance (just-in-time information, data sets, etc.)

In-game communication tools (chat, social tools, etc.)

External community resources (dedicated blog, YouTube, Twitch, forums, etc.)

Figure 18 shows how each of the critical thinking definitions align with game design elements to create the learning framework.





## 9. The Grit Learning Framework



## The Grit Learning Framework



While critical thinking is a long held staple in the learner's bag of 21st-century essential skills, other non-cognitive factors are also being introduced, including "attributes, disposition, social skills, attitudes and interpersonal resources. More and more, research suggests that these factors can be "just as important as intellectual abilities for success" (Sheckman et al., 2013).

Grit is a non-cognitive trait that combines several conditions and dispositions. A person with grit has:

1. A deep interest in the subject matter that builds into passion
2. A clearly defined purpose for which they persevere through hardships
3. Support from family, friends, teachers, mentors and others

In the context of games, the definitions of grit may be further defined as shown in figure 19:



**Figure 19:** Grit Definitions and Sub-definitions



To foster grit, the game must allow the player to...

**1. Build Interest into Passion**

The game should contain design elements that help sustain the interest of the player. These elements range from superficial designs, such as rewards or bonuses, to allowing the player to customize some parts of the game or co-create the game to encourage true passion. One area the framework is not able to measure is the player's personal interest. As it is unique to each individual, it cannot be predicted.

**2. Identify with a Purpose to Persevere**

People who have grit, according to Duckworth, are not only hard working and determined but also have direction. They know what they want (2016). In games, the framework identifies elements

that help the player understand goals, have opportunities for practice and iteration, build competitiveness and have opportunities for planning and sense-making.

### 3. **Gain Support and Feedback**

A factor that is apparent among individuals with grit is the inherent support of others, including family, friends, mentors and teachers. In the framework, support is identified through feedback mechanisms inside and outside of the game. Within the game, support may take on the form of player performance data such as scores or points which is usually presented to the player or retrieved on-demand. It can also take on the form of an added feature such as a chat area that provides players a communication tool, allowing them to draw support from other players. Other support mechanisms can also be found outside the game in the form of gaming communities. Further, for a person with grit to thrive, they must be in an environment that gives them a sense of belonging and acceptance. Games that allow friends to play together provide extra support and confidence to succeed.

Based on the definitions above, these are the corresponding game design elements and the level in which they are able to foster grit:

## 9.1 Build Interest into Passion

- **Level 1** (Low Grit): Rewards, gifts, bonuses, cosmetic amusements, limited choice of add-ons (boosters, etc.)

These game elements are typical designs to encourage the player to return. As children are encouraged by level rewards like stars and badges, these are key motivators for continued gameplay and contribute to the overall fun-factor of the game. Some cosmetic amusements, such as choosing the snake skin pattern and colour in Slither.io, engage the player's interest but don't affect gameplay. Daily rewards like coins or bonuses and in-game currency—such as gems—increase the frequency of play and may contribute to the player's success. However, these elements score low in grit because they are chosen “off the shelf” and rely on the assumption that a player might be interested in some of the elements presented. They are considered superficial, peripheral enhancements at best and are not typically core to the game experience. While they encourage gameplay and certainly add to its enjoyment, they can't sustain interest in the long term and build passion.


- **Level 2** (Moderate Grit): Customization of elements and actions that sustain interest and challenge of overall gameplay.

In Pokémon GO, there's a combination of cosmetic and integral customization factors that ensure players are more likely to stick with the game. From a cosmetic perspective, players choose their avatar and customize their look from head to foot. As the game personifies the player within the game environment, the visual representation of the “trainer to be” bears importance, giving confidence to face other would-be trainers. Beyond the player's image, Pokémon GO's augmented reality feature allows players to choose where they can find Pokémons, i.e. they may go near parks or playgrounds to find grass types. And of course, the player customizes the composition of their strategic team to battle in gyms. The game provides many opportunities for player customization, sustaining interest longer and building passionate gym leaders.

- **Level 3** (High Grit): Creation of elements, actions, worlds that sustain the interest and challenge of overall gameplay.

Games that give players the capacity to create and build their game world are perhaps the highest facilitator of grit. When a player has direct input into what they want their world to be and how they want it to be shaped, the player is sure to return. Minecraft has attracted millions of children to their game specifically because of the sandbox design. Children can collect their own resources (iron ore), fashion them into tools (pick axe) and build unique contraptions (rapid fire dispenser) and elaborate structures—all based on their passion and understanding of the “survival” mechanic in the game world.

Figure 20 illustrates the levels of choice, customization and creation as game design elements that align with the definition of building interest into passion.

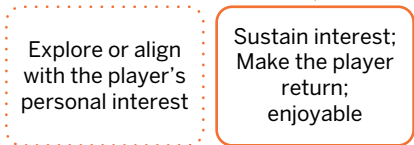


**Figure 20:** Build Interest into Passion Levelled Game Design Elements

Does the game allow the player to...



Build Interest into Passion



Does the game design have...

- LEVEL 1**  
1 point  
Rewards, gifts, bonuses, cosmetic amusements, limited choice of add-ons (boosters, etc.)
- LEVEL 2**  
2 points  
Customization (elements, actions, etc.) that affect sustained interest, challenge of overall gameplay
- LEVEL 3**  
3 points  
Creation (elements, actions, world, etc.) that affect sustained interest, challenge of overall gameplay



## 9.2 Identify with a Purpose to Persevere

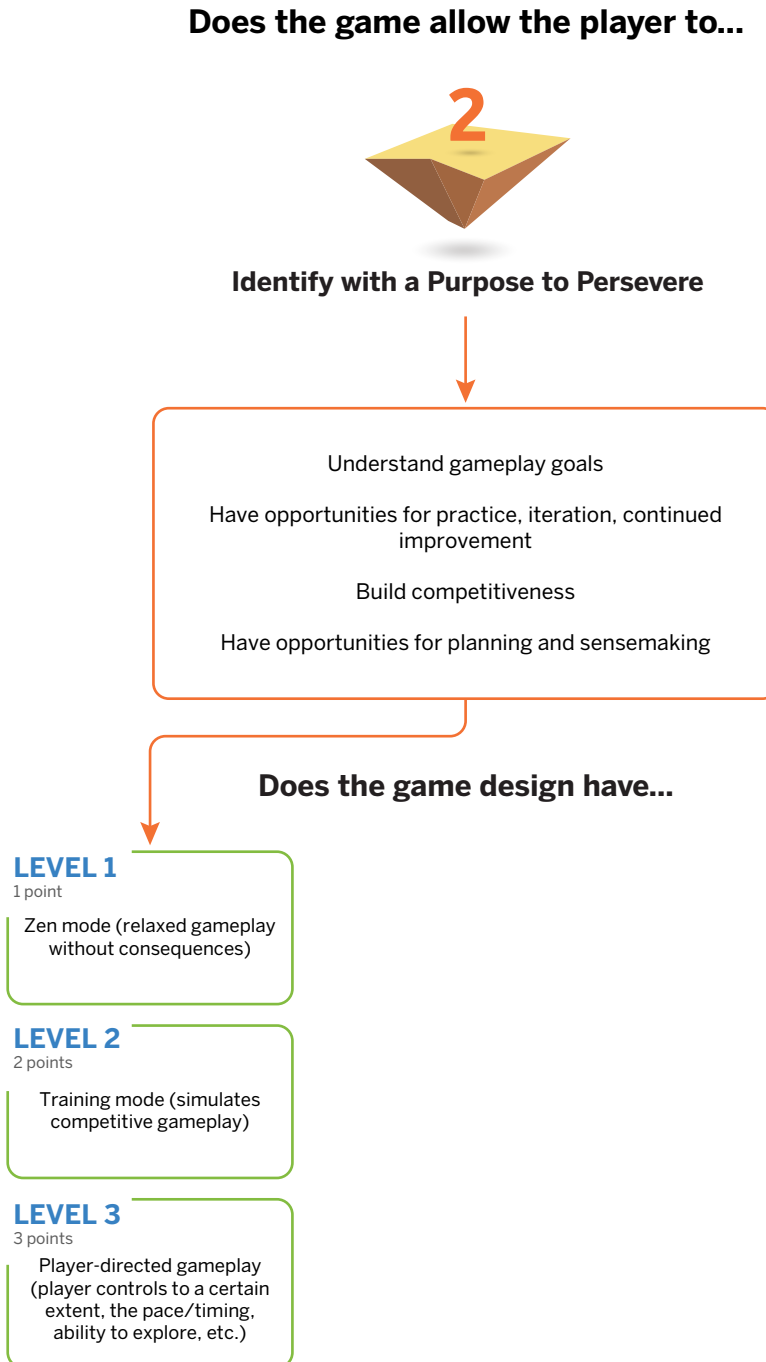
### A. Game Modes

Game modes and goals also affect how much grit can be fostered within digital games. The more a game gives players an opportunity to practice and improve, the more players will understand gameplay goals and the more likely they are to persevere. The game must provide opportunities for sense-making or planning and these are usually manifested in modes that do not constrain the player's abilities; rather, they give them free rein to accomplish success in gameplay.

- **Level 1** (Low Grit): Modes like Zen, relaxed gameplay without consequences
- **Level 2** (Medium Grit): Training mode or modes that simulate gameplay
- **Level 3** (High Grit): Player-directed gameplay; player controls pace, timing, ability to explore, etc.



**Figure 21:** Grit Framework Game Mode Levels



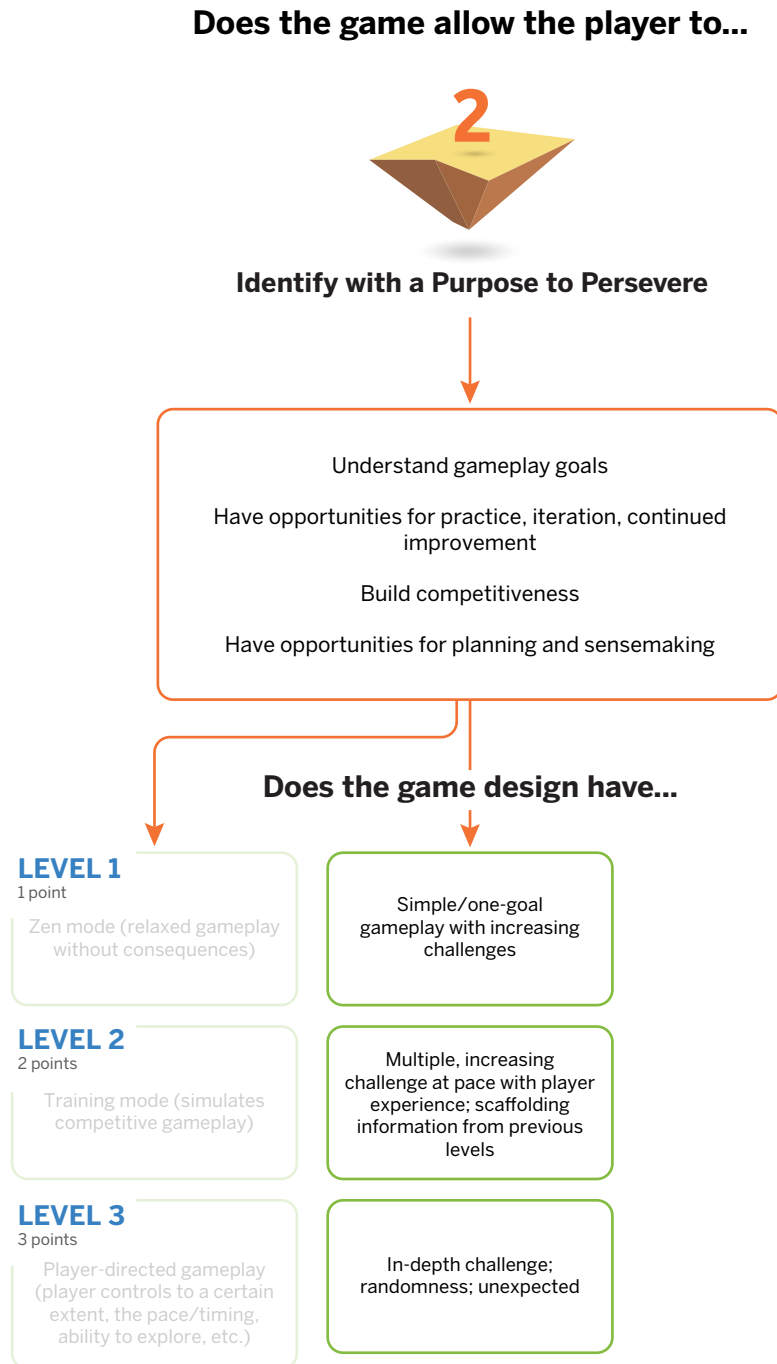
## B. Goals

Challenges that require more player commitment, time to build skill and deeper thinking are typically found in games with multiple, complex goals. The more there is for the player to accomplish, the more they are able to find purpose and the higher the likelihood of playing the game towards mastery.

- **Level 1** (Low Grit): Simple, one-goal gameplay with predictable increase in challenges
- **Level 2** (Medium Grit): Multiple, increasing challenges at pace with the player's experience, scaffolding information from previous levels
- **Level 3** (High Grit): Multiple, complex goals with in-depth challenges, possibly random and unexpected



**Figure 22:** Grit Framework Game Goal Levels



## C. Competitiveness

Games that are designed for multiple players can build loyalty and drive high-frequency gameplay. Competing with real-time opponents adds another layer of challenge that motivates players to succeed. Further, one of the most relevant considerations for the 9-12 age group is the ability to play with their real-world friends. Beyond friendly competition, they can also support each other in games that require cooperation and collaboration to succeed.

- **Level 1** (Low Grit): Solo play; leaderboard
- **Level 2** (Medium Grit): Player vs. player; multiplayer
- **Level 3** (High Grit): Player vs. player; multiplayer; ability to play with friends



**Figure 23:** Grit Framework Game Competitiveness Levels



## 9.3 Gain Support and Feedback

Feedback mechanisms are important in fostering grit, as they provide support within the game ecosystem. The more emergent gameplay is, the more crucial support resources are for the player. Support and feedback mechanisms take on several forms. Some are built in the game as part of the application design while others can be found outside of the game in the form of gaming communities. The following levels describe these in detail:

- **Level 1:** In-game feedback on performance (just-in-time or on-demand information)

In-game feedback can be omnipresent or available upon request. In its most basic form, it comprises scores, lives, health points and levels. Some games provide more actionable data, such as the resource section in Minecraft, which players can access to aid game play decisions. These feedback mechanisms require low grit as they are readily available.

- **Level 2:** In-game communication tools (chat, social tools)

When a game is equipped with extra features such as a chat area, players can seek help from other players. Games that can be played with friends (multiplayer) provide an extra level of support as they can use these communication tools to exchange tips on how to navigate the game, how to achieve a level or how to avoid certain predators. Players who utilize these optional social tools display moderate grit—they take an extra step to understand how to play the game successfully when information is not handed to them easily.

- **Level 3:** External community resources (dedicated blog, YouTube channels, Twitch, forums, etc.)

When there are no instructions and gameplay is fully emergent, support resources are crucial for the player. The player who seeks external resources such as third-party gaming communities for advice demonstrates the highest level of grit.



**Figure 24:** Grit Framework Game Support and Feedback Levels

**Does the game allow the player to...**



**Gain Support & Feedback**



Get help or support as needed  
Have a sense of belonging and acceptance

**Does the game design have...**



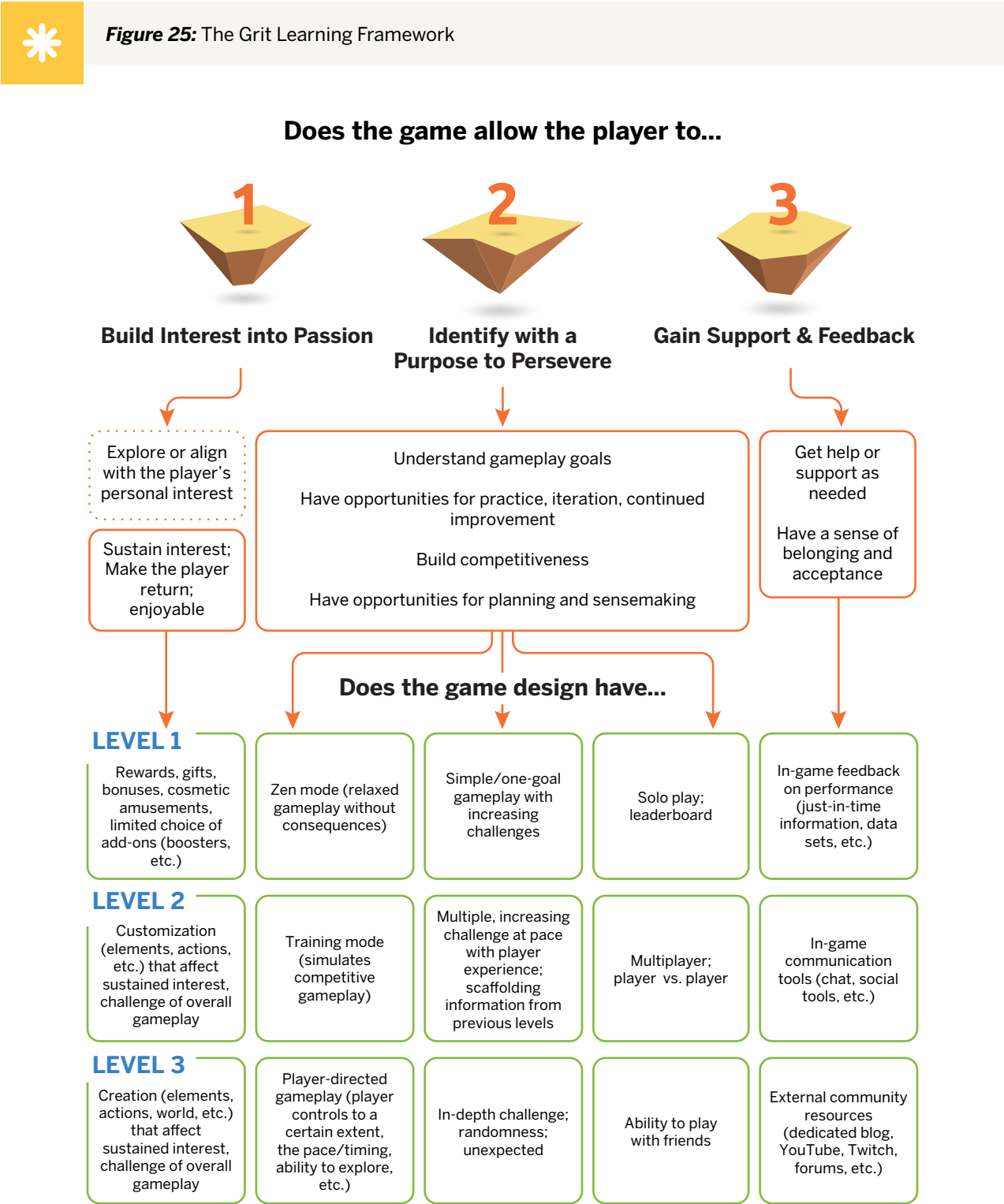
In-game feedback on performance (just-in-time information, data sets, etc.)

In-game communication tools (chat, social tools, etc.)

External community resources (dedicated blog, YouTube, Twitch, forums, etc.)



Figure 25 shows how the definitions have been aligned with levelled game design elements to create the full framework.



## 9.4 Mind the Gaps

While the learning framework developed has mapped out the various definition of skills to effectively show which game design elements can foster them, there are parts of the definition that cannot be easily interpreted as a game design element. For these a different approach might be needed.

According to Ennis (1987), it is not enough to perform thinking operations and tasks, there are dispositions one must have to successfully engage in critical thinking. They are:

- Seek a clear statement of the thesis or question
- Seek reasons
- Try to be well informed
- Use and mention credible sources
- Take into account the total situation
- Try to remain relevant to the main point
- Keep in mind the original or basic concern
- Look for alternatives
- Be open-minded
- Take a position (and change a position) when the evidence and reasons are sufficient to do so
- Seek as much precision as the subject permits
- Deal in an orderly manner with the parts of a complex whole
- Use one's critical thinking abilities
- Be sensitive to the feelings, level of knowledge and degree of sophistication of others

Given that digital games are a safe place to fail (Section 5.1, p. 33), they might encourage the dispositions above, however, the framework cannot know the player's disposition or frame of mind as they enter the gamespace. Will the player explore different solutions, be open-minded, fair, or sensitive to other players? These dispositions are dependent on personality, mood, moral character and one's natural tendencies.

"Personal Interest" forms one of the definitions of grit. It has also been mentioned as one of the influential factors that affect the child's choice of games (Section 10.1.3, p. 94). Personal interest is an expansive topic which may include a child's experiences, motivations, preferences, influences, mood, character and much more. As such, the learning framework is not adequate to measure this; a future study of a different framework of measurement may be suitable.



## 10. Influential Factors in Learning



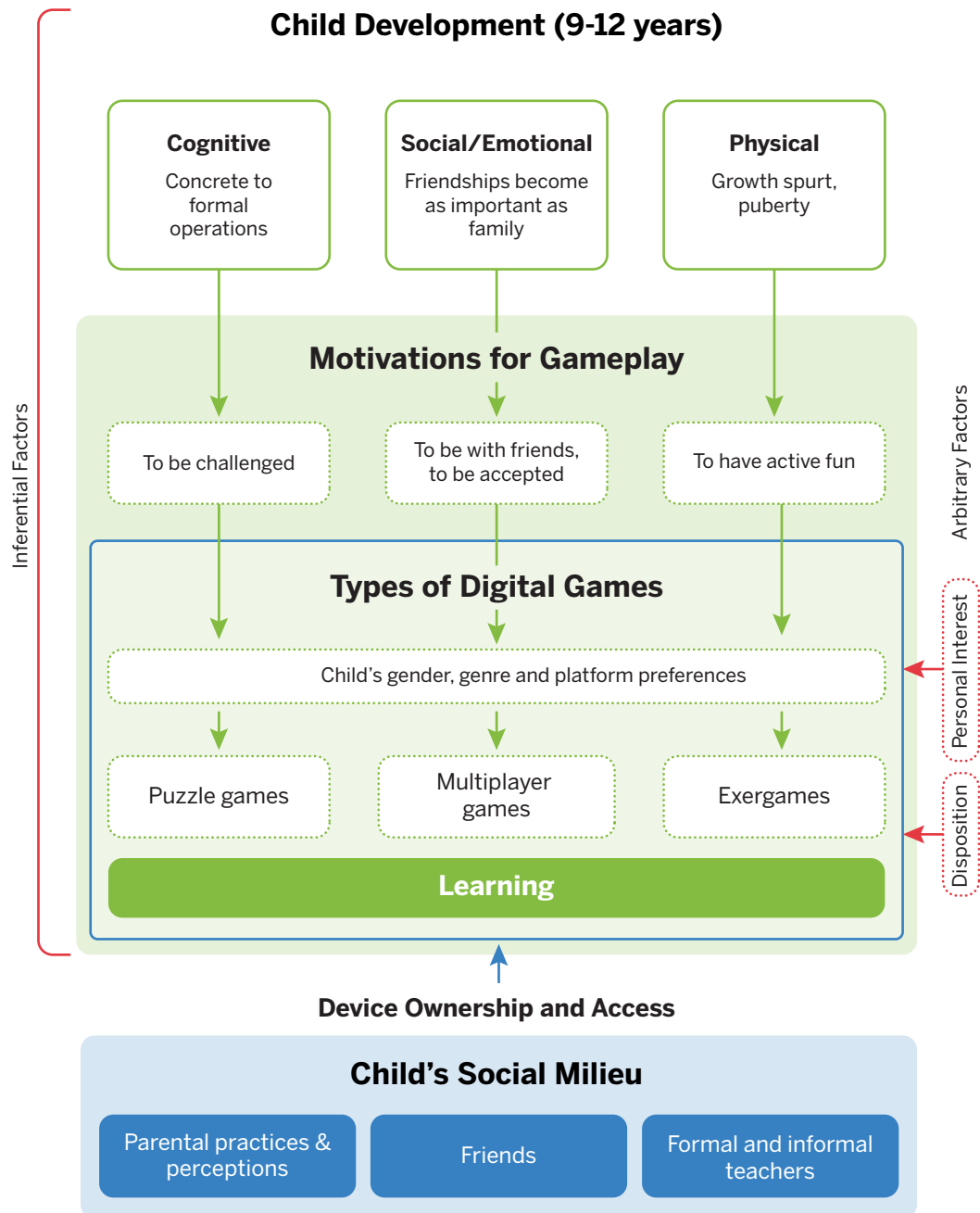
## Influential Factors in Learning



Numerous influential factors contribute to what children may learn in digital games. Figure 26 illustrates how factors like child development, motivations for gameplay and the choice of games are inferential; that is, they lay the foundation to shape the next factor. Some factors are arbitrary, such as the child's personal interest and disposition, making it harder to predict learning outcomes. Ownership and access to games are also fundamental factors that depend on the child's social milieu—the family, friends and teacher network that surrounds the child.



**Figure 26:** Factors That Influence a Child's Learning in Digital Games



## 10.1 Inferential Factors

### 10.1.1 CHILD DEVELOPMENT (9-12 YEARS)

The first critical factor to consider in understanding learning outcomes is the stage of the child's development. The cognitive, social/emotional and physical development of a child varies from one to the next; however, as a cohort, there are characteristics that help define each developmental stage. These milestones provide insight into the child's motivations for playing digital games, which in turn lead to their choice of games. The games and how they are designed, ultimately, dictate the learning outcomes.

Children aged 9–12 are known as preadolescents in psychology, and are commonly referred to as pre-teen or tween<sup>7</sup> in everyday use. This developmental phase is marked by a “period of tremendous intellectual, social-emotional, and physical change. School demands increase, friends become as important as family, and puberty begins to reshape her body. This is also a time when individual differences among children become more apparent” (Firchow, 2004).

The following are developmental themes of pre-teens from the Nelson Textbook of Pediatrics (Kliegman, R. and W.E. Nelson, 2011):

**Physically**, pre-teens experience a growth spurt and secondary sexual characteristics develop toward the end of this stage. Fine and gross motor skills continue to improve. Children may express an interest in joining team sports and games. Due to many physical changes that occur at this stage, their self-concept tends to focus on external characteristics—they may be absorbed in their bodily changes and conscious about their outward appearance.

**Socially**, tweens become more interested in their peer group, especially peers of the same sex. They may prefer to be with friends than parents. Children at this stage want to blend in. One parent notes that, “Peers are playing the same game, in order to fit socially, he wants to play.” This parent understands the social pressure her son is experiencing and his need to belong, but she continues to struggle with his excessive gaming habits (Section 6.1.4, p. 44).

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<sup>7</sup> An American neologism and marketing term coined by the media company, Nickelodeon. The term is a blend of the words “teen” and “between”.

**Cognitively**, tweens transition to logical thinking, reasoning and judgment. These abilities may develop at differing rates during a pre-teen's life.

### 10.1.2 MOTIVATIONS

Understanding a child's developmental stage informs possible motivations for playing digital games. A child who has gained cognitive maturity may be motivated to play games that are challenging, such as puzzles or strategy games that are within their Zone of Proximal Development (ZPD). ZPD is a concept introduced in 1934 by Soviet psychologist, Lev Vygotsky, as the gap between what the child can do independently and what the child can do with some help. It has also been interchanged with the idea of Bruner's scaffolding in education, the use of "support points" as needed to learn and their removal when no longer necessary. In the gaming context, the application of ZPD is manifested in game design by crafting challenges that are neither too easy nor too difficult. The player should be able to solve the problem and be encouraged to move to the next level. Alternatively, children who may not yet have the cognitive maturity and are not interested in complex problem-solving may opt for arcade-style games that rely on the quickness of hand (or fingers) rather than thinking processes.

Socially, children at this stage will most likely choose to play with friends. Games built with online multiplayer or player vs. player modes, where teams can be formed or friends invited are going to be at the top of their list. As this age group is highly influenced by peers, there is social pressure to play games that are the topic of conversation at school. In the parent questionnaire (Section 6.1.4, p. 45), a parent of an 11-year-old boy shared that when her son invited classmates to play Clash Royale, his clan grew from three to 20 members overnight, with some classmates extending the invitation to friends of friends.

A child's physical development may also contribute to the selection of games, especially if it fulfills their desire to be constantly active. Exergames such as Wii Fit U (Wii U), Just Dance 3 (Kinect Xbox 360) and EA Sports Active (Playstation 3) all promote gross motor movement. An added benefit: many studies suggest that exergames enable greater energy expenditure compared to sitting games (Haddock et al., 2012).

### 10.1.3 ARBITRARY FACTORS

While a child's development can give us a sense of their gameplay motivation, there are two factors that are more difficult to predict: the child's personal interest and their disposition. There are a few conclusions that can be drawn by observing these factors. For example, a child who is drawn to Lego or Star Wars will probably choose digital games of the same subject matter, such as the Star Wars: Empire at War strategy game.

If a child's disposition is generally open to experimentation and they are determined in nature, that child may choose and flourish in Minecraft. Alternatively, a child may just be bored and want to pass the time, in which case any arcade style game would fit the bill.

### 10.1.4 TYPES OF DIGITAL GAMES

In addition to cognitive, developmental and idiosyncratic or arbitrary factors, there's also preferences of game genres by gender. Mobile advertising and analytics platform, Flurry (2014) reports specific genres like simulation or management titles skew heavily to females while card/battle games skew male. Categories like arcade and puzzle games remain neutral. The following lists from Flurry Analytics (as cited in Shaul, 2014) outline the genres most often played by females, males and both genders respectively:

#### **Mobile Game Genre Preferences by Gender** (Flurry Analytics, 2014)

The following genres are played more often by females:

- Endless runners
- Brain/quiz
- Social turn-based
- Bingo
- Match 3/bubble shooter
- Casino/poker
- Slots
- Solitaire
- Management/simulation



The following genres are played more often by males:

- Action – RPG
- Shooter
- Sports
- Tower defense
- Strategy
- Card/battle

The following genres do not indicate more play-time by males or females:

- Physics/puzzle
- Racing
- Platformer
- Arcade

While genre preferences by gender are not surprising, Nofziger (2014) argues that platform assortment, not gender, drives gaming differences, “This diversity has largely been driven by the evolution of hardware and the introduction of new platforms that allow for unique experiences. From PCs to consoles and designated handhelds, from the family-friendly Wii to smartphones and tablets; each of these has given rise to unique gameplay and allowed players to fit video games into their lives in new ways.” Game experiences are indeed tailored to each platform and understanding a platform’s usability strengths—like portability—and weaknesses—such as screen real estate—is fundamental to game development. But gender is an important variable when players choose platforms. While consoles and PCs have traditionally skewed male, the mobile platform skews female (EEDAR, 2015). This evidence aligns with Flurry data that indicates women spend more on in-app mobile purchases than men (Flurry Analytics, 2015). The combination of gender, genre and platform all play a role in game preference.

## 10.2 Child’s Social Milieu

Access to devices and the games on them is also dependent on the child’s “social milieu.” This refers to the relevant groups of people that surround the child at this stage in their life. These are parents, family, friends, formal or informal teachers in and outside of school.

## 10.2.1 PARENTS AND FAMILY

While relationships with friends strengthen, parents remain influential figures at the pre-teen developmental stage. Parental practices vary when it comes to digital gaming depending on their own personal experiences, perceptions and understanding of the media. Some parents are gamers themselves and will play games with their kids while others don't play games at all. Studies show that moms are dominating the gaming demographic, "In 2014, social gaming network PlayPhone found that 68% of mobile gamers are women and 71% of those women are married. In 2012, Mom Central Consulting found that 70% of women play casual games regularly" (as cited in Levere, 2015).

When asked in the parent questionnaire (Section 6.1.4, p. 44), "What are your conditions or rules, if any, regarding screentime and/or playing with digital games in general?" the following responses and patterns emerged:

### 1. **The Weekday/Weekend Split**

Parents were almost evenly split in their practice of allowing kids to play digital games during weekdays (55%) and only during weekends (45%). For those that allowed gaming during school nights, parents required that homework and other priorities such as reading or practicing piano be completed before playing digital games.

### 2. **Kids Get More Screentime Than Allowed**

About 31% of parents noted that their kids are always begging for extra playtime after the allotted time is up. Famous excuses were, "Need to finish one more thing, five more minutes, I'm in the middle of something, I need to check something..." Additionally, a couple of parents noted that negative behaviour emerges when the negotiation is not going in the child's favour.

### 3. **Few Parents Stick with the AAP's Recommendation on Screentime**

About half of the parents had specific screentime limits. Twenty-five per cent allowed up to one hour a day; (18%) up to two hours and (6%) up to three hours. The other half (50%) did not mention any specific hours. A few noted that they don't necessarily have any formal time limits but instead monitor casually with consequences if their rules are not followed. One parent shared that they used a timer to closely monitor gameplay.

#### **4. The Rules Can Be Gray**

A couple of parents remarked that gaming rules are hard to define. Every now and then they encounter something new that they did not account for and need to revisit their conditions. This was echoed by a parent who said they find it hard to have any “clear cut rules.” Sometimes they allow mini game breaks when their child is working hard at schoolwork but other times demand the child finishes school work in anticipation of a busy weekend. This is further complicated when their child is at a friend’s home and the parenting styles on gaming are more liberal. Since they don’t want their child to feel socially excluded, they give in.

#### **5. Device Location Matters**

A parent shared that they don’t worry about late-night gaming because devices are left in the kitchen at night, while another parent admits that the iPad lives in her child’s bedroom.

### **Game Download Practices and Parental Considerations**

The findings on how games are downloaded revealed parents download digital games the majority of the time (56%) compared to kids downloading it by themselves (31%). A small percentage (1%) claim both parent and child share the action (Section 6.1.3, p. 43).

This finding is aligned with the Electronic Software Ratings Board’s (ESRB) research showing that 86% of parents are aware of the rating system and 73% regularly check a game’s rating before making a purchase (“esrb.org,” 2016).

### **Tweens’ Device Ownership**

Device ownership is, by and large, the root component of access to digital gaming. According to The Common Sense Census: Media Use by Tweens and Teens, “Even among lower-income tweens, a large majority (71%) do have tablets at home, and nearly half (48%) have their own tablets. But higher income tweens have much greater access: 89% percent have one in the home, 56% have their own and 71% use one at least weekly.” Of the total time spent on tablets, 27% is used for playing games, the highest percentage of time in any activity spent, followed by watching online videos at 16% and listening to music at 10% (2015).

**Table 3:** Tablet Ownership and Use Among Tweens, by Family Income

Tablet Access/Habits	All Tweens	Lower	Middle	Higher
Have a tablet in the home	80%	71%	80%	89%
Have their own tablets	53%	48%	53%	56%
Use a tablet at least weekly	63%	55%	64%	71%

*Note.* “Lower” income is defined as <\$35,000; “middle” is \$35,000-99,000; and “higher” is \$100,000 or more. All figures in USD. Reprinted from The Common Sense Census: Media Use by Tweens and Teens (Publication). (2015).

According to the Common Sense Census, most tweens (79%) live in a home where there is at least one smartphone. The same report reveals that about 24% of tweens have their own.

**Table 4:** Smartphone Ownership and Use Among Tweens

Smartphone Access/Habits	Among Tweens	Among Teens
Smartphone in the home	79%	84%
Have their own smartphone	24%	67%
Use a smartphone “every day”	21%	64%
On any given day, percent who use	22%	58%
Average time among those who use	3:35	4:38
Average time among all	:48	2:42

*Note.* Reprinted from The Common Sense Census: Media Use by Tweens and Teens (Publication). (2015).

### 10.2.2 FRIENDS

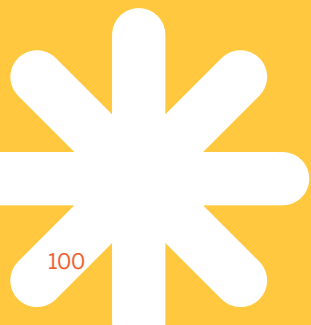
Device access is not limited to a family's ownership. A child visiting a friend's home or spending time with a friend who owns a device is more likely to engage in digital gameplay. With the aforementioned ownership statistics on tablet and smartphones, digital gaming is most likely on the menu of activities on a playdate. It is not uncommon to hear of conflicting parental practices, including issues like other parents allowing more screentime or mature rated gameplay, especially if the child has older siblings. "It makes me uncomfortable, but I've noticed that a lot of parents don't appreciate it when I ask that they not play any video games during the playdate—it's viewed as trying to control what happens in their home, or as some judgment upon them for allowing the younger child to play age-inappropriate games" (as cited in "cmch.tv," 2009).

### 10.2.3 FORMAL AND INFORMAL TEACHERS

Schools, day camps and libraries are other settings where the child may have access to devices. Depending on device availability, frequency in which they are allowed to interact and the norms and rules around such interaction can define a child's access. Schools, for example, may allow gaming during downtime or as part of the curriculum. Day camps with STEM subjects deliberately include devices as part of their lesson plans. Gaming in libraries is a growing trend across Canada and the United States. With fewer teen visits and books checked out, librarians worry that they are losing a generation of readers. There is increasing evidence that gaming events will increase circulation and reading among young adults. In the U.S., they are augmenting their books with video games and tournaments as a decoy to bring back teens into libraries, attempting to ignite an interest in books (Navarrete, 2013). In Canada, the Toronto Public Library includes gaming in their programming, offering after school, lunch-time and evening gaming and gaming clubs. Tech Soup for Libraries believes that gaming events can "draw teens and parents to the library, create a connection between young adults and library staff and help teens develop teamwork and organizational skills" (2016). Tech Soup for Libraries believes gaming can be beneficial, "There's no universal consensus on this controversial issue, but there's a lot of evidence suggesting that well-designed games improve fluid intelligence and one's ability to solve complicated, multifaceted problems." Tech Soup for Libraries is a project of the non-profit, Tech Soup, initially funded by The Bill and Melinda Gates Foundation.



## 11. Conclusion



# Conclusion



## HOW MIGHT DIGITAL LEISURE GAMES FOSTER CRITICAL THINKING AND GRIT?


The 15 digital leisure games reviewed possess game design elements that can foster critical thinking skills and grit. The degree to which the skills are enabled depends upon the type of game design elements. Further, a pattern has emerged: some of the **same game design elements** can foster both skills.



**Figure 27:** Digital Leisure Games That Foster Critical Thinking

Low	Medium	High
Crossy Road 26%	Cooking Fever 40%	Clash Royale 73%
Fruit Ninja 33%	Pac-Man 256 40%	Pokémon GO 80%
Stick Hero 33%	Mimpi Dreams 40%	Human Resource Machine 86%
Piano Tiles 33%	Candy Crush 40%	Monument Valley 86%
	Slither.io 40%	Minecraft 100%
	Plants vs. Zombies 60%	

Of the 15 digital leisure games reviewed, five games (33%) have been found to foster the highest degree of critical thinking: Minecraft (100%), Monument Valley (86%), Human Resource Machine (86%), Pokémon GO (80%) and Clash Royale (73%). Six games (40%) ranked moderate and four games (26%) ranked low in critical thinking.



**Figure 28:** Digital Leisure Games That Foster Grit

Low	Medium	High
Crossy Road 26%	Cooking Fever 40%	Human Resource Machine 80%
Stick Hero 33%	Fruit Ninja 40%	Clash Royale 80%
Mimpi Dreams 33%	Pac-Man 256 40%	Pokémon GO 80%
	Piano Tiles 40%	Minecraft 100%
	Candy Crush 40%	
	Slither.io 43%	
	Monument Valley 66%	

For grit, four games (26%) have been found with the highest degree: Minecraft (100%), Pokémon GO (80%), Clash Royale (80%), and Human Resource Machine (80%). Three games (20%) ranked low and eight games (53%) ranked moderate.

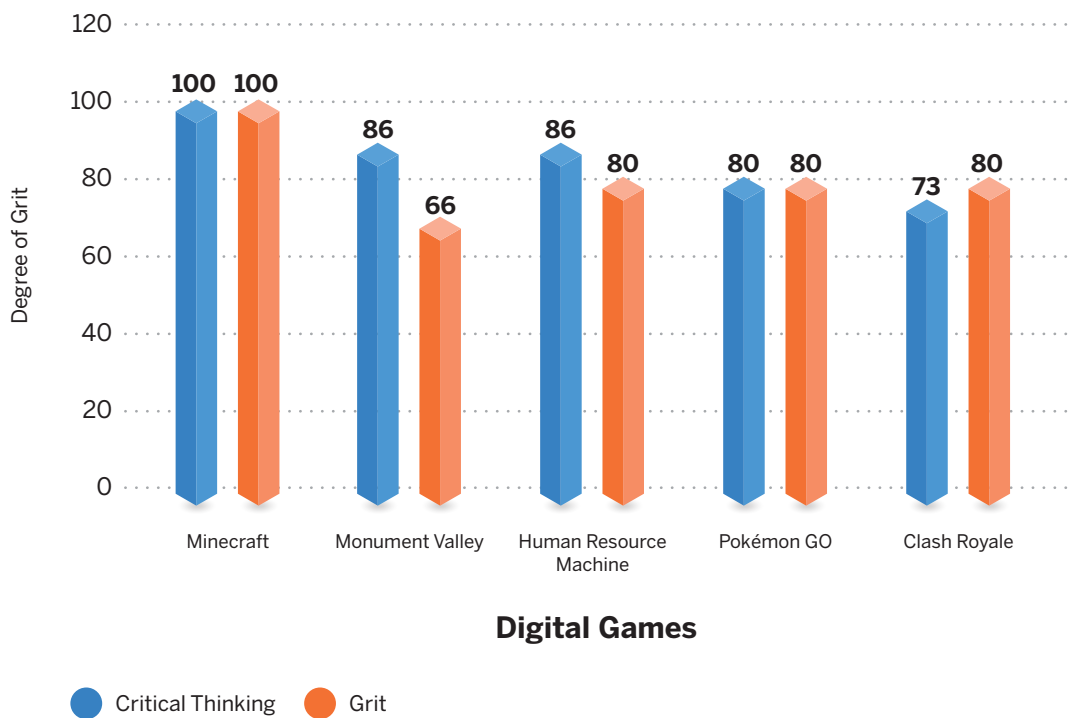


Combining the games that score high on both critical thinking (CT) and grit (G), the top games in either category remain the same with the exception of Monument Valley which was shy of 5% to have made it to the high scores.

Games like Minecraft (CT: 100%; G: 100%) and Pokémon GO (CT: 80%; G: 80%) scored equally on both skills while games like Human Resource Machine (CT: 86%; G: 80%) and Clash Royale (CT: 73% G: 80%) show scores with a marginal difference of 6-7%. Monument Valley is the only game that has a difference of 20% between its critical thinking and grit scores. Perhaps its moderate grit score can be attributed to the fact that the game only has 10 levels, which are easily achievable. The closeness of the scores for both skills suggest there are similar game design characteristics present in these games to have scored equally or closely.



**Figure 29:** Top Digital Leisure Games That Foster Both Skills



## 11.1 Game Design Elements That Foster Both Critical Thinking and Grit at a High Degree.

Critical thinking is a cognitive skill while grit is a non-cognitive trait. They may differ from each other but similar game design elements can promote them within digital games.

### 1. Self-directed, Emergent Games

Based on the digital games reviewed, Sandbox mode or games that are non-linear and include random and unexpected gameplay foster high-level critical thinking. Players have autonomy over the speed of gameplay, actions, decision-making and exploration. Such games usually have emergent gameplay with rules that are subtle, sometimes even hidden. Under these conditions, the player is required to engage in deeper critical thinking, gathering knowledge, comprehending and analyzing how the game is played and then synthesizing information to create new strategies, actions or elements. In the natural course of replaying the game, the player will learn to evaluate and reflect on their decisions and the critical thinking cycle can begin again. Or, as previously pointed out in Clash Royale, the critical thinking cycle happens several times within just one battle. The less information given to the player, the harder they need to think about the gameplay.

The same type of game criteria applies to grit. If a game allows players to choose their actions and navigate on their own without barriers, they are playing the game based on their own level of interest—a prerequisite to building the passion that ultimately fuels grit.

### 2. Modes That Allow Creation, Building

Closely related to self-directed games are games that allow players to create or build their own assets, like building a shelter in Minecraft or assembling troop cards in Clash Royale or forming a Pokémon team in Pokémon GO. Synthesis, a fundamental cognitive process in critical thinking, is defined as combining ideas to form a new whole. Within games, synthesis happens in activities like creating, combining, constructing, designing or rearranging a new element or action that affects the success of gameplay. In games that have been assessed to have high critical thinking and grit, **the process of synthesis is present**. In games that score low to moderate, there is little to no evidence of this cognitive processing. Low to moderate scoring games are usually designed with a pre-determined set of choices not allowing the player to create anything new.

Additionally, games that allow players to create assets or design their game world score particularly high in grit. These games give players the flexibility and freedom to fashion their game

based on their personal interest as opposed to being constrained with choices that may not align with what they like.

### **3. Multiple, Complex Goals and Challenges**

Games with many goals, some of which may start out small and build, usually allow the player to experience three to five of the critical thinking processes synchronously and in a cyclical pattern throughout the gameplay. For example, the battles in Clash Royale require the player to determine, under a time constraint, which cards from their deck they will deploy into the battle arena for defense, offense or both (comprehension, application, analysis, knowledge). Typically, these types of games involve strategy, battle or action as with Pokémon GO, Minecraft and Clash Royale. These games are also usually designed to increase challenges over time as the player builds their skills toward mastery. The ability of a game to allow the player to practice, iterate and develop skills at pace with time invested is an important aspect of developing grit.

### **4. Internal and External Communication Support Mechanisms**

There are two types of communication support mechanisms that foster both critical thinking and grit skills to a high degree. The first can be found within the game application in the form of a communication tool such as a chat feature that allows feedback and information exchange between players. These communication tools are usually found in social, multiplayer games (e.g. Minecraft, Clash Royale) and enable real-time exchanges in games that require cooperation, collaboration and shared responsibility to win. The social interaction among players, who may be friends in real life, is important in enabling grit. It's best fostered when players feel well supported and have a sense of belonging.

The second type of communication support is found outside the game application. Games that readily present performance feedback such as overt narratives or explicit instructions do little to foster critical thinking. In contrast, emergent games, as previously discussed, allow discovery in and outside of the game. Emergent games allow players to uncover feedback through experience and because information is not handed out easily, players seek communities of practice like gaming blogs or video channels to find the information they need. Gee (2007) refers to this as the "affinity space," an external structure with a special interest in games where a lot of knowledge, comprehension and analysis takes place.

## 11.2 Learning Insights From Game Genres

Game genres might give us clues to whether critical thinking and grit can be fostered in digital leisure games but it is not definitive. The 15 digital leisure games reviewed were mapped onto market research firm, Electronic Entertainment Design and Research (EEDAR) mobile game genre classification of core<sup>8</sup> to casual<sup>9</sup> games (Figure 30: Digital Leisure Game Genres). Based on the top scoring games, RPG/strategy (Clash Royale, Plants vs. Zombies) and Action (Minecraft, Pokémon GO), critical thinking is likely fostered in these genres more so than arcade games (Fruit Ninja, Stick Hero, Crossy Road, Slither.io, Pac-Man 256). These observations might seem obvious as the genre names likely suggest the type of thinking required for the games. However, games in the same genre can have varying degrees of critical thinking and grit that making any generalization would be inaccurate. For example, in strategy, tower defence games such as Plants vs. Zombies scored 60% on critical thinking but Clash Royale, also a tower defence game, scored 73%. In the puzzle genre, critical thinking scores wildly differ. Candy Crush at 40% (matching puzzle), Mimpí Dreams at 40% (platformer puzzle combined with adventure) and top scorers Human Resource Machine at 86% and Monument Valley at 86% do not even have a defined puzzle sub-genre, perhaps because they are unique. The other noticeable factor is the time investment in puzzle games. As they are broad/casual in appeal, the time invested would be far less than what RPG/strategy and action games require, yet Monument Valley comes with the second best score (86%) after Minecraft (100%).

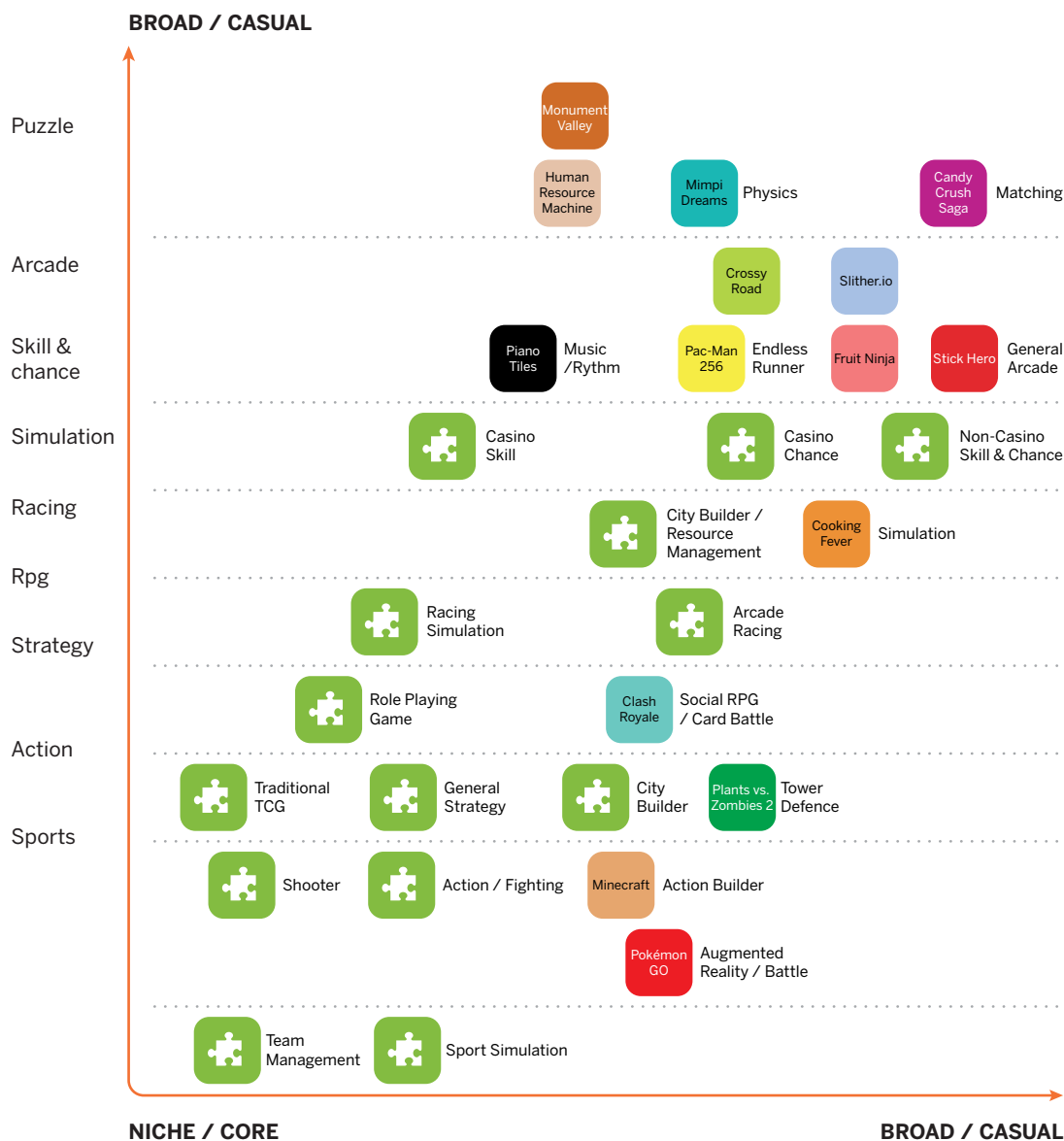
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<sup>8</sup> Core games - more niche in their appeal, requiring greater investment, focus and skill to meaningfully participate.

<sup>9</sup> Casual games - broadly appealing, highly accessible experiences, requiring minimal investment and skill to be successful.



**Figure 30:** Digital Leisure Game Genres



**Note.** EEDAR's Mobile Game Genre classifies from core to casual based on how much investment they require from the player to enjoy the experience. Investment is affected by many factors including price, session length, rule complexity, controls, multiplayer and twitch gameplay. Adapted from Deconstructing Mobile and Tablet Gaming 2015.

Similar patterns and genres are identified with game that scored high in grit. Minecraft (100%), Pokémon GO (80%), and Clash Royale (80%) are all from the RPG/strategy and action genres. Human Resource Machine, tied in the second spot at 80% and Monument Valley, with a moderate score of 66% are both puzzle games.

## 11.3 The Cost of Free-to-Play Games

The digital leisure games that scored high in both skills come in Free-to-Play (F2P) and paid versions. Here are the revenue classifications:

- Minecraft – Paid
- Clash Royale – Free-to-play
- Monument Valley – Paid
- Pokémon GO – Free-to-play
- Human Resource Machine – Paid

In all paid games, players are not interrupted by the need to wait 24 hours for a booster to unlock or a daily reward to earn new lives to become available. They are free to continue playing without interruption, allowing for the potential to develop critical thinking skills and grit. In contrast, free-to-play games often feature moderate to persistent pushes to purchase in-app purchases. These can be a hindrance or a deterrent to gameplay. Among the free-to-play games reviewed, Clash Royale and Pokémon GO, are the only two whose commercial pushes don't get in the way of gameplay. Even though the purchases will provide greater ease of play and quicker advancement, the player can continue with their strategies and gameplay without buying anything. Other titles, such as Candy Crush and Plants vs. Zombies, heavily push in-app purchases. If the player refuses to buy in-game currency and other rewards, their player "lives" are limited or time-based rewards are forced upon the player. This means the game's pace is considerably slower and the challenges become more difficult, if not impossible, to complete without a purchase. This was especially true in Cooking Fever. In this game, a player is required to upgrade cooking equipment so that cooking time is faster and more customers can be served. The only way to upgrade is by purchasing gems, the in-game currency. If the player doesn't purchase the gems, they can't move up a level and customers leave grumpy. This observation suggests that F2P game formats may lower the player's skills if they make in-app purchases to get through the game faster or more easily. If that is the case, then F2P formats may be deceiving players into thinking they can win when in fact, no amount of skills, critical thinking or grit will really help.

### SOME FREE-TO-PLAY ARE PLAY-TO-WIN MODELS

Parents who download free-to-play games (Section 6.1.3. p. 43) don't always fully understand how detrimental these types of games can be to their child's learning grit and critical thinking skills. Free-to-play games typically promote instant gratification. Children behave differently based on their inherent

disposition—some will grind it out to achieve higher levels while others, perhaps with lower grit, will easily give into in-app purchases and become dependent on acquiring boosters and extras to achieve level completion. Game design in free-to-play games are inextricably linked to pricing models. At the outset, game designers decide how much they will allow the player to succeed on their own vs. how much the player needs to purchase to continue to advance. For instance, some game developers want their investment on the application development within a few weeks and that should provide enough knowledge of how the game would operate. Good games aim to balance game design and their pricing model so that skilled players have a chance to win even against the so called “wallet warriors”—players who will pay to be first on the leaderboards.

## 11.4 Learning Expectations & Outcomes

At the onset of the research, learning expectations regarding the capacity to foster critical thinking skills and grit in the games were noted (Table 1, p. 9). These were based on the researcher’s understanding of the games, including their genres, descriptions and personal perceptions. With the exception of the classic version of Pac Man, the researcher had never played any of the games until this study. The outcomes are somewhat mixed. Five out of 15 games were expected to have low critical thinking scores but moved up at least one level higher in the outcomes. This is true for games like Candy Crush Saga, Clash Royale, Cooking Fever, Slither.io and especially Pokémon GO which leaped two levels from low to high. For grit, the opposite pattern was observed. Six out of 15 games were expected to score high and instead moved down a level. These were Candy Crush Saga, Pac-Man 256, Piano Tiles, Plants vs. Zombies, Slither.io and most notable is Stick Hero which moved down two levels from high to low. Human Resources Machine was the only game that moved up a level from moderate to high. The inflated expectations on the grit scores is largely based on its popularity and the initial perception, of how “addictive” a game can be. Clearly, those are incorrect definitions.

**Table 5:** Learning Expectations and Outcomes

Game	Genre	Expectations (Critical Thinking / Grit)	Outcomes (Critical Thinking / Grit)
Candy Crush Saga	Puzzle (Matching)	L/H	M/M
Clash Royale	Strategy / Tower Defence / Card Battle	M/H	H/H
Crossy Road	Endless Arcade	L/L	L/L
Cooking Fever	Simulation / Time Management	L/M	M/M
Fruit Ninja	Arcade (General)	L/M	L/M
Human Resource Machine	Puzzle / Logic	H/M	H/H
Mimpi Dreams	Puzzle / Adventure / Platformer	M/L	M/L
Minecraft	Sandbox / Action Builder	H/H	H/H
Monument Valley	Puzzle / 4D	M/M	H/M
Pac-Man 256	Endless Runner / Arcade	M/H	M/M
Piano Tiles	Music / Arcade	L/H	L/M
Plants vs. Zombies	Strategy / Tower Defense	M/H	M/M
Pokémon GO	Action Battle / Augmented Reality	L/H	H/H
Slither.io	Arcade	L/H	M/M
Stick Hero	Arcade / Physics	L/H	L/L

**Note.** Level of Skill: L= Low, M=Medium, H=High; Blue text denotes no change in outcome, purple denotes change from expectations.



## 11.5 Parent Practices & Perceptions

### 1. **Top Concern: Managing Screentime**

It appears that the main concern for parents is the time their children spend on devices and their ability to maintain balance with other activities like being with friends, reading or participating in sports. The engaging nature of games translates into more screentime than most parents like. One parent noted that they are learning the pull of addiction and how games penalize the player for not coming back daily to the point that the kids get anxious if they don't comply, "It's interesting to see that the kids are well-educated about drug and alcohol addiction, but don't recognize that they display the same behaviours at times when it comes to digital games."


### 2. **Top Consideration in Choosing Games: Age-appropriate Content**

The research is clear: learning takes a back seat to games that are age-appropriate. While some research suggests violent video games may actually lead to the development of empathy, understanding and even moral behavior (Van Eck, 2015), it is apparent that parents of children in the 9-12 age group place age-appropriate content at the top of their consideration hierarchy. "Teaches 21st-Century Skills" and "Positive Character Traits" ranks next in parents' considerations. These two are tied with a score of 2.3, which suggests that parents may equally value both. "Fun and Entertaining, Free" ranks third. And "Teaches Academic Content" came in last, suggesting that parents may not see digital games as a possible medium of classroom instruction.

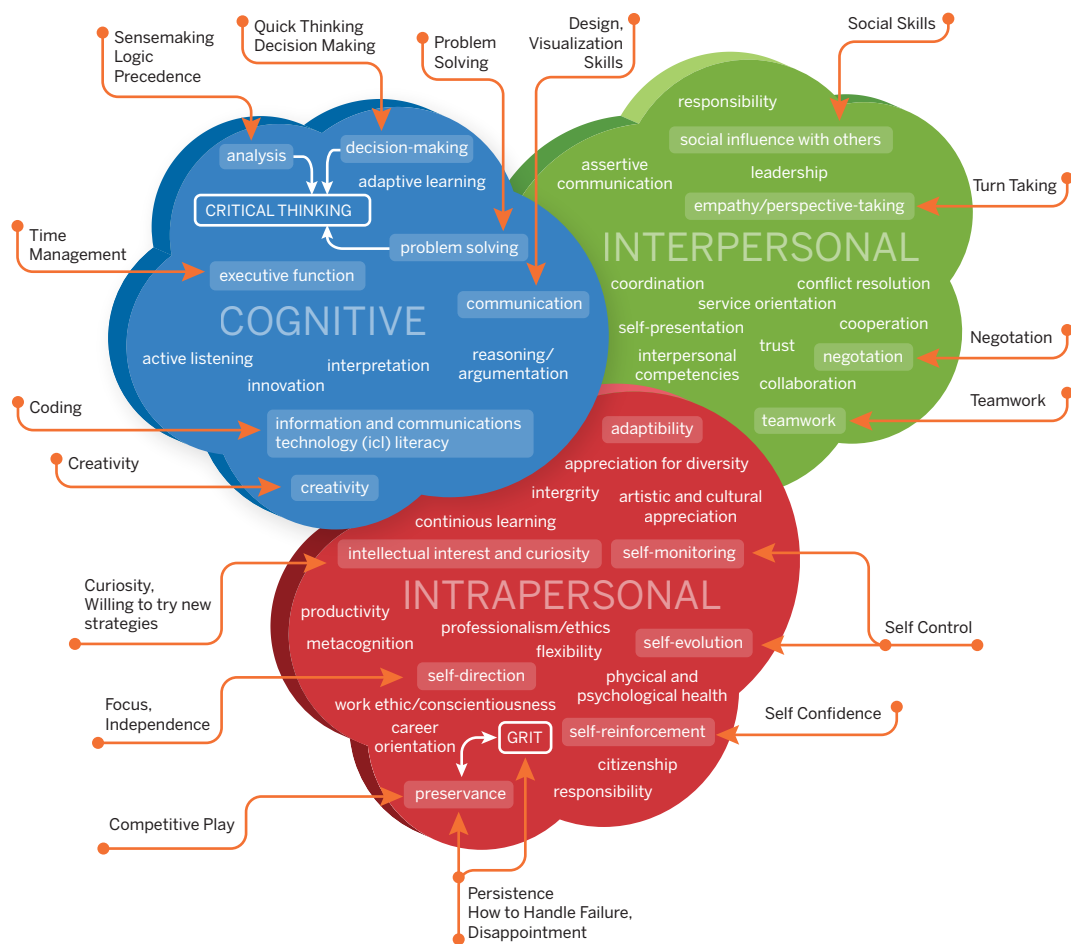
### 3. **Parent's Learning Perceptions Are Congruent with 21st-Century Skills**

Despite 70% of parents revealing that they were surprised to find some digital games foster critical thinking and grit (Section 6.2.2 p. 48), they were aware that kids were learning something. Parents shared many cognitive, intrapersonal and interpersonal skills when asked what they think their children may be learning from digital games.

Overlaying parent’s perceptions on learning with the National Research Council’s (NRC) 21st-century skills grouping (2012), the terms mentioned by parents are aligned, demonstrating that perhaps parents do acknowledge the potential to learn 21st-century skills while playing digital games. Further, with some clustering, parents may already know that critical thinking and grit can be fostered in digital games as well. The words *problem solving, decision making, quick thinking, sense-making, logic and precedence* are all parts of the critical thinking definition. Words like *persistence, how to handle failure, disappointment, competitive play, focus and independence* are traits that form or are closely related to the definitions of grit.



**Figure 31:** Parents Learning Perceptions and 21st-Century Skills



**Note.** Labels with orange dots are parent responses (Section 6.1.5, p. 46); connecting lines and arrows point to the corresponding skills adapted from National Research Councils’ 21st-century skills grouping (2012).

## 11.6 Further Study and Future Directions

### 11.6.1 FOR GAME DEVELOPERS: AGENCY

Game developers intent on fostering 21st-century competencies such as critical thinking and grit need to consider a core element in their game design—**player agency**. Giving players the influence and power to co-create the game fosters these competencies to the fullest. Specifically, games should be designed to be self-directed, giving the player control over the creation of artifacts to strategic solutions. Games should increasingly challenge the player with multiple, complex goals with little to no instructions—emergent gameplay allows for best use of the skills. And last, games should allow for internal support through the ability to play with friends and peers. When no such features are available, it should encourage players to seek external gaming communities for support. Player agency may be most pertinent for educational game developers to consider beyond designing for content knowledge outcomes alone. It can increase player engagement and boost the fun factor—something educational games are not necessarily known for.

### No Girl Left Behind

Additionally, game developers should consider designing games that engage both genders. Flurry analytics (Section 10.1.4, p. 94) suggest that males play strategy, role-playing and action games more than females. Given that these game genres have been observed to have higher scores of critical thinking and grit compared to those most often played by females (arcade and matching puzzle games), this presents a concern that girls might be left out in developing these skills. Game developers can take a page from the current wave of initiatives that aim to empower girls in subjects where boys typically dominate, like STEM. From day camps (coding for girls) to toys (engineering kits), there are now several organizations that strive to create gender equity.

**Research Opportunity:** A follow-up investigation on games most often played by girls may provide further insight on if and how they may be able to foster 21st-century competencies. Given that the majority of the participants of this study have male children, the current findings can be cross-referenced and new insights might emerge.

## 11.6.2 FOR PARENTS: AWARENESS

The results of this study found several contradictory data from parents. From acknowledging the challenge of screentime yet allowing gaming on school nights and having no set limits, to conflicting views on 21st-century learning, to downloading mostly free-to-play games, it is apparent that parents lack awareness on the true value of digital leisure games. Parents need guidance on understanding the unfavourable aspects and the benefits of digital leisure games, including 21st-century competencies.

### 1. Parents, Play with Your Kids

The best way for parents to understand games is to play them with their children particularly for pre-teens who may not be as communicative with parents. Sinem Siyahhan, assistant research professor in Sanford School of Social and Family Dynamics, explains that games can be a point of conversation, not conflict. She also adds, “On the flip side, it’s nice for the child to be able to teach his or her parents about gaming (“Move Over, Monopoly,” 2013). Parents should see this experience as an equitable learning opportunity for both. Researchers from Arizona State University say that, “Parents miss a huge opportunity when they walk away from playing video games with their kids. Often parents don’t understand that many video games are meant to be shared and can teach young people about science, literacy and problem solving. Gaming with their children also offers parents countless ways to insert their own ‘teaching moment.’” (“Move Over, Monopoly,” 2013). Parents should approach screentime as family time—it cultivates family bonding time, learning and well-being.

### 2. There’s an App for That

While the feedback on the learning framework was generally positive (Section 6.2.4, p. 49), parents suggested that a more concise and easy-to-interpret format would be more user-friendly. The feedback also suggested that it would benefit parents with children who play digital games the most. Given the pervasiveness of mobile devices among parents (and kids), turning the learning framework into a mobile application may be fitting.

**Research Opportunity:** Growing the digital games database to include more parent contributions will strengthen findings and perhaps provide new insights. Over time, the learning framework can also be extended to include other essential 21st-century competencies. It can aim to be the de facto tool for discovering 21st-century learning in digital games.

### 11.6.3 FOR TEACHERS: ADAPTATION

While the majority of teachers are comfortable using digital/video games in the classroom (Section 3.2, p. 15-16), this study has uncovered many challenges they continue to face. The ability and willingness to adapt to using digital games for learning is key.

- **Teaching Style**—Are teachers willing to consider incorporating dialogic learning—the transfer of knowledge from students? Games can play a key part in fostering a dialogic style of teaching as they are part of a social learning system (Section 5.3, p. 35). And learning is always reciprocal with them; learning can flow from teacher to student, student to teacher and even students can learn from each other.
- **Beyond Educational Games**—With the insight that specific game design elements can foster critical thinking and grit (Section 11.1, p. 104), teachers have the ability to adapt digital games, which may not necessarily be educational, for their classroom use. Mobile games require shorter periods of gameplay compared to PC-based games, which most teachers use. As time is a common constraint (Section 3.2, p. 15), mobile games may provide a suitable alternative.
- **Consideration for Disengaged Learners**—Digital games are a hands-on, active learning medium. For disengaged learners who do not respond well to traditional methods, highly engaging digital games can be a solution. As noted with innovative game-based learning schools (Section 3.2, p. 17-18), their student (and teacher) retention and successful learning outcomes are high along with successful learning outcomes.

21st-century frameworks have existed for several years now. How they are executed in schools tends to be a hodgepodge of STEM-themed after-school clubs, some project-based learning and the teacher's own interpretation, if they even have the capacity to address this part of the curriculum. The knowledge of how digital leisure games may foster critical thinking and grit might offer solutions to an already tapped out educator facing challenges in how to execute 21st-century learning.

### 11.6.4 GOING FOR THE HIGHER LEVELS

- **Summative Testing**—To strengthen the learning framework, a summative testing of the frameworks in collaboration with game developers and educators is ideal to further assess and develop consensus around the game design elements and levels identified. Further investigations might yield qualified iterations that may best reflect a comprehensive range of games and genres.

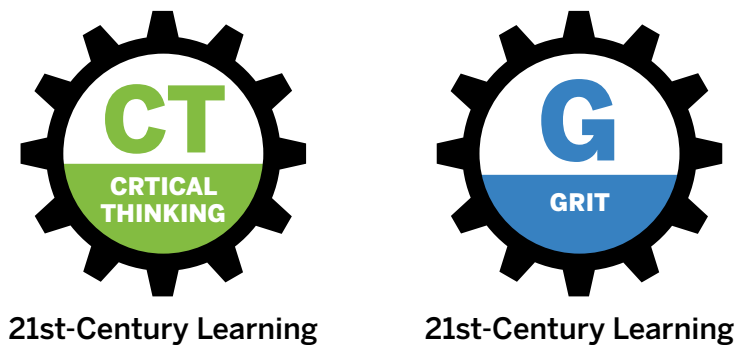
Similarly, getting feedback from educators on how they might use the learning framework is equally valuable.

- **Transferability**— While the findings of this study have suggested that certain game design elements may foster critical thinking and grit, the subsequent question for further study is how the skills might transfer to real-life settings and what types of measurements will best determine its transferability. These are considerable questions, as even game-based educators struggle with finding reliable systems of assessment in teaching content knowledge through games (Section 3.2, p. 20). Trying to measuring cognitive, intrapersonal and interpersonal skills may be an even bigger challenge. However, creating that rubric and criteria for scoring in the game space would be invaluable.

#### 11.6.5 THE MARK OF 21<sup>ST</sup>-CENTURY LEARNING



**Figure 32:** 21st-Century Learning Badges



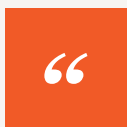
*Note.* Proposed 21st-Century learning badges which can be applied to digital games that foster critical thinking and grit.

While the ESRB's content rating guide satisfies the needs of parents who want to know that games are age-appropriate, the 21st-century learning badge seeks to identify digital games that foster essential competencies such as critical thinking and grit. This new way to curate digital games gives parents,

educators and general consumers a purposeful and confident choice in supporting their desire to teach 21st-century skills to children.

The Learning Framework mobile application (Section 11.6.2, p. 114) can be offered to all stakeholders as an instrument that allows them to score and check if their chosen game has the ability to foster such skills. Possible partnerships with learning through games advocacy organizations can help spread awareness about the learning badge by adopting it as a standard when reviewing digital games and through their advocacy work (workshops, speaking engagements, etc.) Partnerships with game developers can also be instrumental as they can use the learning badge as a way of promoting their games and eventually, other game developers may also follow suit. Ultimately, partnerships with digital game distribution platforms are key to widespread awareness and adoption.

There's also an opportunity to work with educators who are passionate and already using digital games for learning. In understanding more of their needs and using the framework to identify which games are best for their classroom, teachers can be advocates that not only use the framework but can spread awareness through their schools and to the parents of their students. For teachers who are just beginning to use digital games in the classroom and may not be getting adequate support from their districts (Section 3.2, p. 18-19), workshops using the learning framework can provide support in choosing the appropriate games. There is no pre-determined path but perhaps by understanding the needs of the stakeholder community and how this framework might best serve them, awareness can grow. Every small action can lead to greater adoption.



*Video games are, at the heart, problem solving spaces that use continued learning and provide pathways to mastery through entertainment and pleasure (Gee, J.P., 2009).*

Even digital/video games designed primarily for entertainment provide some pedagogical value, including scaffolding, forced moments of analysis and reflection, graphical or textual mnemonic devices, feedback mechanisms and learning to assess relationships and values within the game world. 21st-century skills such as critical thinking and grit are fostered most in games that give players maximum agency to define their game world.

Even when kids (and their parents) aren't aware of its presence, they're being taught by an invisible teacher.

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# Appendix

## APPENDIX A: 15 DIGITAL LEISURE GAMES REVIEWED

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## Appendix A: **Digital Leisure Games Reviewed**



# 1. Pokémon GO

**Genre:** Action Battle / Augmented Reality

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**Version:** Free

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**Rated:** 9+

---

As a Pokémon trainer, the task is to catch as many Pokémon types to win battles. In the early stages, the trainer needs to build up knowledge and comprehension of where to efficiently find Pokémon (e.g. water types are close to lakes), what essentials are needed (Pokéstops replenish balls, lures and such) and learn the types of strengths and weaknesses. The game builds the trainer's experience before engaging in battle and provides just-in-time and on-demand information as a guide.

Once allowed to battle, the cognitive operations of comparing, prioritizing, reasoning and making inferences happen when the trainer chooses a gym and assembles the best line-up of Pokémon for combat. Gyms will have a reigning Pokémon and will stay there until it has been beaten. The battle itself may just be a series of taps and swipes. It's the decision making regarding who to battle (like comparing type and combat points), which Pokémon or combinations to choose, the order of attack (like greatest to least combat points) and how to approach the attack (such as dodging to preserve health points or go full force) that matter most.

The opportunities for sense-making happen throughout the gameplay, especially since only basic rules are made apparent to the trainer, the rest of the strategies are emergent and learned through experience such as building Prestige (level) in a gym by using a lower CP (combat point) Pokémon to attack.

Post-battle, the trainer will have time for reflection, especially if the battle is lost. The decision-making cycle repeats itself and soon the trainer will discover that the strategic combination of catching specific types of Pokémons (and other tactics like powering up, evolving, hatching eggs or transferring) will yield better results in battle. Collecting the best Pokémon may involve in-game currency such as Candy and Stardust. Though it is possible to play the game without making any purchases, you may need to walk many, many miles and play often.

The game moves the player from catching to battling and gaining experiences to improve battle outcomes. The levels increase based on the trainer's experience. The challenges are self-directed since trainers choose the gyms to battle and they can go as slowly or as aggressively as they desire. Throughout the game, there are many mini goals that not only sustain interest but are tools necessary for a successful future battle. These might be hatching Pokémon eggs, collecting lures or Pokéballs. Though this game has often been referenced as a social game because it draws people out to meet in public spaces, it is also socially-oriented within the game. Trainers can join teams and battle together or defend a gym—shared goals increase participation. As analysis is necessary for a strategic choice of Pokémon, the game provides informational support through the Pokédex, Pokémon profiles, Journal and Appraise functions.

As more people play the game, gyms become harder to take down—perhaps this and another holy grail, finding a rare Legendary Pokémon, make trainers persevere. Will players' interest in the game last? Perhaps, if there are in-game communication tools, some ability to trade cards and more customization for trainers to create their strategies.



**Figure 1:** Pokémon GO Score Cards

## Critical Thinking Score: 80%

### LEVEL 1

Instruction/guides	Non-timed gameplay; Zen mode without consequences	Limited choice of elements, actions, etc. that affect gameplay strategy	Simple/one-goal gameplay with predictable increase in complexity	In-game feedback on performance (just-in-time information, data sets, etc.)
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### LEVEL 2

Some instructions; some emergent gameplay	Training mode (simulates competitive gameplay)	Customization of elements, actions, etc. that affect gameplay strategy	Multiple goals/considerations, increasing in challenge at pace with player experience; some predictability	In-game communication tools (chat, social tools, etc.)
---	--	--	--	--

### LEVEL 3

No instructions, fully emergent gameplay	Non-linear or player-directed gameplay (player controls to a certain extent, pace, timing, ability to explore, etc.)	Creation of elements, actions, world, etc. that affect gameplay strategy	Multiple goals with in-depth challenge; randomness; unexpected gameplay	External community resources (dedicated blog, YouTube, Twitch, forums, etc.)
--	--	--	---	--

POINTS 2

3

2

2

3

**Total: 12/15 (80%)**

## Grit Score: 80%

### LEVEL 1

Rewards, gifts, bonuses, cosmetic amusements, limited choice of add-ons (boosters, etc.)	Zen mode (relaxed gameplay without consequences)	Simple/one-goal gameplay with increasing challenges	Solo play; leaderboard	In-game feedback on performance (just-in-time information, data sets, etc.)
--	--	---	------------------------	---

### LEVEL 2

Customization (elements, actions, etc.) that affect sustained interest, challenge of overall gameplay	Training mode (simulates competitive gameplay)	Multiple, increasing challenge at pace with player experience; scaffolding information from previous levels	Multiplayer; player vs. player	In-game communication tools (chat, social tools, etc.)
---	--	---	--------------------------------	--

### LEVEL 3

Creation (elements, actions, world, etc.) that affect sustained interest, challenge of overall gameplay	Player-directed gameplay (player controls to a certain extent, the pace/timing, ability to explore, etc.)	In-depth challenge; randomness; unexpected	Ability to play with friends	External community resources (dedicated blog, YouTube, Twitch, forums, etc.)
---	---	--	------------------------------	--

POINTS 2

3

2

2

3

**Total: 12/15 (80%)**

## 2. Monument Valley

**Genre:** Puzzle

---

**Version:** Paid

---

**Rating:** 4+

---

The player helps Princess Ida navigate her way through M.C. Escher inspired towers. At each level, called chapters, new challenges are introduced, scaffolding the knowledge of the player to help solve the puzzles. The towers form optical illusions and the player needs to manipulate walls, staircases and pathways to find a path for Ida to pass. There are obstacles like Crow people and hotspots which trigger walls or reveal pathways. This game allows for player-directed exploration where trial and error is encouraged. In solving the puzzle, the player simultaneously thinks about cause and effect, ordering and searching while constructing assumptions and conclusions.

It may favour visual thinkers as it requires visual-spatial cognition and the ability to mentally manipulate up to four-dimensional figures. While there is a reasonable amount of analysis in discovering the solution, the chapters end with only one solution to every puzzle. It removes the player's ability to come up with multiple solutions.

The sense of accomplishment after each puzzle fuels the player's desire to solve the next one. However, with a pre-determined solution to each chapter, the player will get stuck at some point and without any in-game guide, it can be frustrating. The imaginative graphics and stimulating puzzles are great for sustaining interest but the game is only 10 chapters long. Some players have been asking for more.





**Figure 2:** Monument Valley Score Cards

## Critical Thinking Score: 86%

### LEVEL 1

Instruction/guides

Non-timed gameplay;  
Zen mode without  
consequences

Limited choice of  
elements, actions,  
etc. that affect  
gameplay strategy

Simple/one-goal  
gameplay with  
predictable increase  
in complexity

In-game feedback on  
performance  
(just-in-time  
information, data  
sets, etc.)

### LEVEL 2

Some instructions;  
some emergent  
gameplay

Training mode  
(simulates  
competitive  
gameplay)

Customization of  
elements, actions,  
etc. that affect  
gameplay strategy

Multiple  
goals/considerations,  
increasing in challenge  
at pace with player  
experience; some  
predictability

In-game  
communication  
tools (chat, social  
tools, etc.)

### LEVEL 3

No instructions,  
fully emergent  
gameplay

Non-linear or  
player-directed  
gameplay  
(player controls to a  
certain extent, pace,  
timing, ability to  
explore, etc.)

Creation of elements,  
actions, world, etc.  
that affect gameplay  
strategy

Multiple goals with  
in-depth challenge;  
randomness;  
unexpected gameplay

External community  
resources (dedicated  
blog, YouTube,  
Twitch, forums, etc.)

POINTS 3

3

2

2

3

**Total: 13/15 (86%)**

## Grit Score: 66%

### LEVEL 1

Rewards, gifts,  
bonuses, cosmetic  
amusements, limited  
choice of add-ons  
(boosters, etc.)

Zen mode (relaxed  
gameplay without  
consequences)

Simple/one-goal  
gameplay with  
increasing challenges

Solo play;  
leaderboard

In-game feedback on  
performance  
(just-in-time  
information, data  
sets, etc.)

### LEVEL 2

Customization  
(elements, actions,  
etc.) that affect  
sustained interest,  
challenge of overall  
gameplay

Training mode  
(simulates  
competitive  
gameplay)

Multiple, increasing  
challenge at pace with  
player experience;  
scaffolding  
information from  
previous levels

Multiplayer;  
player vs. player

In-game  
communication  
tools (chat, social  
tools, etc.)

### LEVEL 3

Creation (elements,  
actions, world, etc.)  
that affect  
sustained interest,  
challenge of overall  
gameplay

Player-directed  
gameplay (player  
controls to a certain  
extent, the  
pace/timing, ability to  
explore, etc.)

In-depth challenge;  
randomness;  
unexpected

Ability to play with  
friends

External community  
resources (dedicated  
blog, YouTube,  
Twitch, forums, etc.)

POINTS 1

3

2

1

3

**Total: 10/15 (66%)**

### 3. Crossy Road

**Genre:** Endless Arcade

---

**Version:** Free

---

**Rating:** 9+

---

Players take on a character that hops across the road through traffic and moving rivers, avoiding obstacles like vehicles, swooping birds and more. The simplicity of this one-gesture game allows the player to grasp the goal within seconds of playing it. There are no other elements of gameplay that enable deeper analysis or reasoning. Instead, success in this game requires great hand and eye coordination and timing one's hops (finger tap) through a moving maze of obstacles.

The game design has cosmetic amusements to keep the player returning, such as earning coins to purchase different characters like a lovely bunny, a runner, or a box of fish and chips. There's also the discovery of how to unlock mystery characters like the Phone Box, Nessie or Michael Bloom (one of the developers). Some characters unlock backgrounds like the Mummy that transforms the city roads into a nighttime Halloween setting. The characters and settings may change, but the mechanics largely stay the same. These tactics are entertaining for the short term but are not substantial in fostering grit.



**Figure 3:** Crossy Road Score Cards

## Critical Thinking Score: 26%

<b>LEVEL 1</b>	Instruction/guides	Non-timed gameplay; Zen mode without consequences	Limited choice of elements, actions, etc. that affect gameplay strategy	Simple/one-goal gameplay with predictable increase in complexity	In-game feedback on performance (just-in-time information, data sets, etc.)
<b>LEVEL 2</b>	Some instructions; some emergent gameplay	Training mode (simulates competitive gameplay)	Customization of elements, actions, etc. that affect gameplay strategy	Multiple goals/considerations, increasing in challenge at pace with player experience; some predictability	In-game communication tools (chat, social tools, etc.)
<b>LEVEL 3</b>	No instructions, fully emergent gameplay	Non-linear or player-directed gameplay (player controls to a certain extent, pace, timing, ability to explore, etc.)	Creation of elements, actions, world, etc. that affect gameplay strategy	Multiple goals with in-depth challenge; randomness; unexpected gameplay	External community resources (dedicated blog, YouTube, Twitch, forums, etc.)
<b>POINTS</b>	1	0	1	1	1

**Total: 4/15 (26%)**

## Grit Score: 26%

<b>LEVEL 1</b>	Rewards, gifts, bonuses, cosmetic amusements, limited choice of add-ons (boosters, etc.)	Zen mode (relaxed gameplay without consequences)	Simple/one-goal gameplay with increasing challenges	Solo play; leaderboard	In-game feedback on performance (just-in-time information, data sets, etc.)
<b>LEVEL 2</b>	Customization (elements, actions, etc.) that affect sustained interest, challenge of overall gameplay	Training mode (simulates competitive gameplay)	Multiple, increasing challenge at pace with player experience; scaffolding information from previous levels	Multiplayer; player vs. player	In-game communication tools (chat, social tools, etc.)
<b>LEVEL 3</b>	Creation (elements, actions, world, etc.) that affect sustained interest, challenge of overall gameplay	Player-directed gameplay (player controls to a certain extent, the pace/timing, ability to explore, etc.)	In-depth challenge; randomness; unexpected	Ability to play with friends	External community resources (dedicated blog, YouTube, Twitch, forums, etc.)
<b>POINTS</b>	1	0	1	1	1

**Total: 4/15 (26%)**

## 4. Cooking Fever

**Genre:** Simulation / Time-management

---

**Version:** Free

---

**Rating:** 4+

---

The goal is to operate a food establishment by keeping customers happy. Starting out in a fast food restaurant, the player gains experience and will have options to purchase other restaurants like a bakery, the concession at FC Barcelona and more. Each restaurant's menu is different and challenges increase. The player is given a step-by-step, just-in-time demonstration on how to prepare and serve food to the customers. The process of sense-making, planning and prioritizing happens in two stages. First, while serving the customers, the player needs to decide how much food to prepare in advance and which customer to serve first, considering the timing and the volume of the order in relation to other customers' orders. While this is happening, the player may arrive at conclusions about which food takes longer to cook, how long customers can wait before deciding to leave and how fast the food needs to be served to get tips. The second stage happens shortly after the level ends. The player can decide to upgrade equipment (for quicker service and to produce more food), upgrade ingredients (to be able to charge more) or upgrade interiors (to increase tips and wait times).

While the premise of parallel cognitive processing sounds great, after purchasing two restaurants, the player's success seems to be hinged on achieving upgrades with less emphasis on strategic thinking. For example, if you upgrade to an automatic cooker, you're almost guaranteed to get three stars and pass a level. The caveat is, upgrades require coins and gems earned through hours upon hours of gameplay or through in-app purchases. If you're willing to spend to level up, there won't be that much in the way of critical thinking.



**Figure 4:** Cooking Fever Score Cards

## Critical Thinking Score: 40%

<b>LEVEL 1</b>	Instruction/guides	Non-timed gameplay; Zen mode without consequences	Limited choice of elements, actions, etc. that affect gameplay strategy	Simple/one-goal gameplay with predictable increase in complexity	In-game feedback on performance (just-in-time information, data sets, etc.)
<b>LEVEL 2</b>	Some instructions; some emergent gameplay	Training mode (simulates competitive gameplay)	Customization of elements, actions, etc. that affect gameplay strategy	Multiple goals/considerations, increasing in challenge at pace with player experience; some predictability	In-game communication tools (chat, social tools, etc.)
<b>LEVEL 3</b>	No instructions, fully emergent gameplay	Non-linear or player-directed gameplay (player controls to a certain extent, pace, timing, ability to explore, etc.)	Creation of elements, actions, world, etc. that affect gameplay strategy	Multiple goals with in-depth challenge; randomness; unexpected gameplay	External community resources (dedicated blog, YouTube, Twitch, forums, etc.)
<b>POINTS</b>	1	0	2	2	1

**Total: 6/15 (40%)**

## Grit Score: 40%

<b>LEVEL 1</b>	Rewards, gifts, bonuses, cosmetic amusements, limited choice of add-ons (boosters, etc.)	Zen mode (relaxed gameplay without consequences)	Simple/one-goal gameplay with increasing challenges	Solo play; leaderboard	In-game feedback on performance (just-in-time information, data sets, etc.)
<b>LEVEL 2</b>	Customization (elements, actions, etc.) that affect sustained interest, challenge of overall gameplay	Training mode (simulates competitive gameplay)	Multiple, increasing challenge at pace with player experience; scaffolding information from previous levels	Multiplayer; player vs. player	In-game communication tools (chat, social tools, etc.)
<b>LEVEL 3</b>	Creation (elements, actions, world, etc.) that affect sustained interest, challenge of overall gameplay	Player-directed gameplay (player controls to a certain extent, the pace/timing, ability to explore, etc.)	In-depth challenge; randomness; unexpected	Ability to play with friends	External community resources (dedicated blog, YouTube, Twitch, forums, etc.)
<b>POINTS</b>	2	0	2	1	1

**Total: 6/15 (40%)**

## 5. Slither.io

**Genre:** Arcade

---

**Version:** Free

---

**Rating:** 4+

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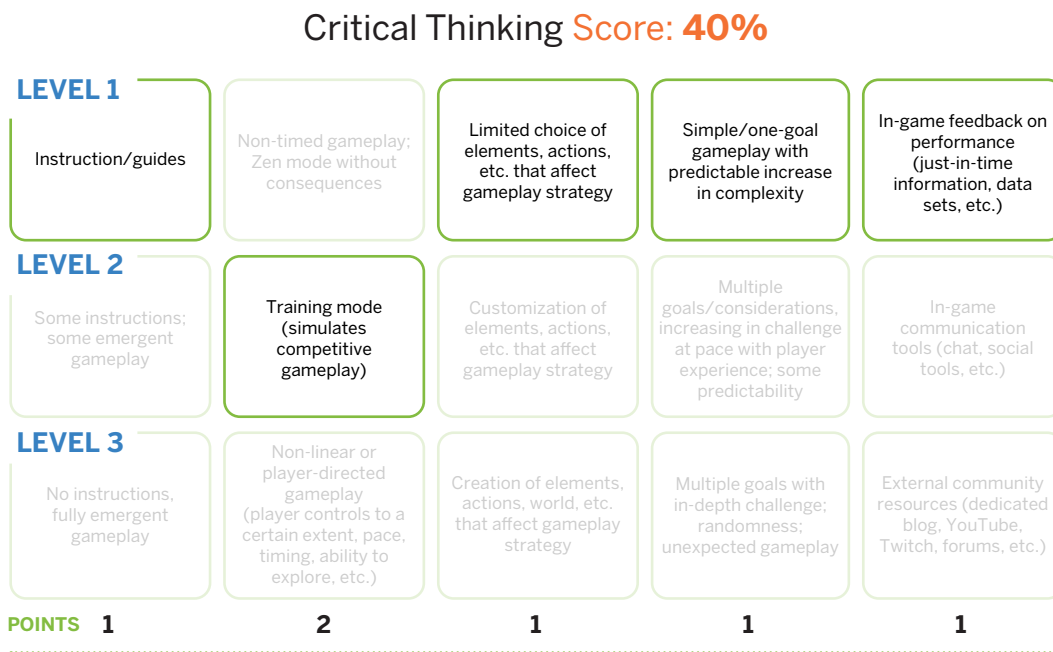
Players grow their snake as large as possible by eating pellets while navigating around other snakes and avoiding death by colliding with their head. The larger your snake is, the easier you can kill smaller snakes and capture their pellets for quick growth. This game has no instructions; instead, emergent tactics such as learning to coil or boost to trap and kill other snakes are learned through experience.

The comprehension and analysis of the gameplay are quickly realized within the first few minutes. There is no other cognitive complexity required by the player. Once the tactics are learned, survival is dependent on developing one's sensorimotor skills to slither masterfully in a predatory environment.

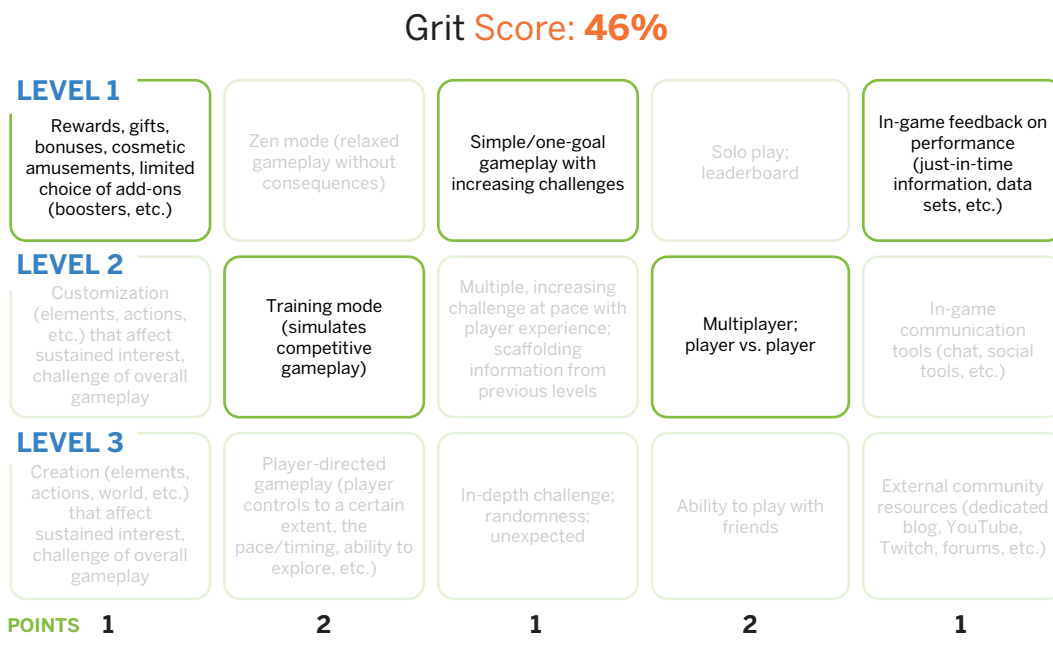
The simple gameplay is accessible to beginners. More experienced players might aim for the leaderboard. The AI (Artificial Intelligence) mode allows the player to practice slithering before joining the more competitive multiplayer mode. There are no levels. Instead, the challenge is dependent on the current competition online and one's skills. These factors may influence the game's re-playability however, in the long run, the game mechanics may seem so trivial that the novelty wears out fast.



**Figure 5:** Slither.io Score Cards



**Total: 6/15 (40%)**



**Total: 7/15 (46%)**

## 6. Candy Crush Saga

**Genre:** Puzzle / Matching

---

**Version:** Free

---

**Rating:** 4+

---

This three-to-complete puzzle uses candies with challenge variations. The first few levels will help the player build knowledge about the different elements of the gameplay such as identification and creation of special candies and how to use boosters. As levels increase, new challenges may be introduced such as clearing the plastic, getting fruits to reach the bottom, limiting time or moves, score goals—or a combination of any of these.

It is highly possible to play this game with pure luck as the candies presented at each level are randomized. For levels above 20, however, planning with a chess-like approach may be necessary to clear the level. This seemingly simple game can quickly become complicated as the player needs to recognize patterns to form a special candy and its combinations, and figure out how to maneuver them into the best position possible. In essence, players sequence and analyze their moves to solve a problem. The free-to-play version aggressively pushes store purchases by limiting boosters and lives. The player is given five lives, and it takes 30 minutes of gameplay to receive one new life (2.5 hours to restore all five). In the hard levels, it's easy to get stuck and the game appears to prioritize monetization and purchasing boosters over critical thinking. Perhaps this game is what gamers call a “pay-to-win” model.

The ease of play in the initial levels convinces the player to return, but around the Lemonade Lake level, it suddenly gets harder. Despite the paywall roadblock, this game wants players to come back daily and rewards them with the Treat Calendar and Daily Spinner to gain boosters (with limits of one or two). Occasionally, players may be invited to try out a game in the higher levels. A key factor in sustaining player interest is the ability to play with friends (especially when you need to ask them to give you a “life”). These tactics are designed to foster “re-playability” but not for the longer-term development of grit.





**Figure 6:** Candy Crush Saga Score Cards

## Critical Thinking Score: 40%

<b>LEVEL 1</b>	Instruction/guides	Non-timed gameplay; Zen mode without consequences	Limited choice of elements, actions, etc. that affect gameplay strategy	Simple/one-goal gameplay with predictable increase in complexity	In-game feedback on performance (just-in-time information, data sets, etc.)
<b>LEVEL 2</b>	Some instructions; some emergent gameplay	Training mode (simulates competitive gameplay)	Customization of elements, actions, etc. that affect gameplay strategy	Multiple goals/considerations, increasing in challenge at pace with player experience; some predictability	In-game communication tools (chat, social tools, etc.)
<b>LEVEL 3</b>	No instructions, fully emergent gameplay	Non-linear or player-directed gameplay (player controls to a certain extent, pace, timing, ability to explore, etc.)	Creation of elements, actions, world, etc. that affect gameplay strategy	Multiple goals with in-depth challenge; randomness; unexpected gameplay	External community resources (dedicated blog, YouTube, Twitch, forums, etc.)
<b>POINTS</b>	1	0	1	2	2

**Total: 6/15 (40%)**

## Grit Score: 40%

<b>LEVEL 1</b>	Rewards, gifts, bonuses, cosmetic amusements, limited choice of add-ons (boosters, etc.)	Zen mode (relaxed gameplay without consequences)	Simple/one-goal gameplay with increasing challenges	Solo play; leaderboard	In-game feedback on performance (just-in-time information, data sets, etc.)
<b>LEVEL 2</b>	Customization (elements, actions, etc.) that affect sustained interest, challenge of overall gameplay	Training mode (simulates competitive gameplay)	Multiple, increasing challenge at pace with player experience; scaffolding information from previous levels	Multiplayer; player vs. player	In-game communication tools (chat, social tools, etc.)
<b>LEVEL 3</b>	Creation (elements, actions, world, etc.) that affect sustained interest, challenge of overall gameplay	Player-directed gameplay (player controls to a certain extent, the pace/timing, ability to explore, etc.)	In-depth challenge; randomness; unexpected	Ability to play with friends	External community resources (dedicated blog, YouTube, Twitch, forums, etc.)
<b>POINTS</b>	1	0	2	1	2

**Total: 6/15 (40%)**

## 7. Clash Royale

**Genre:** Strategy / Tower Defence / Card Battle

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**Version:** Free

---

**Rating:** 9+

---

Players battle each other in real-time with the goal of destroying more towers than their opponents or by destroying the “King’s Tower,” which yields an instant three-crown victory. Any newcomer is first taken to training camp, earning a deck of cards which contain troops (giant, bomber, knight, etc.) with various attack styles and strengths. During the battle, the player is given a “hand” of four cards and must decide which cards to deploy throughout the fight.

A new card is added from the deck each time a card is used. Cards are powered by an elixir number which acts as a timer (1 elixir = 1 second). If a card has an elixir count of eight, the player must wait 8 seconds before the card can become active. Trophies are awarded to victors and deducted from losers—they determine the level of arena, a unique battleground a player can battle in. A certain number of trophies allow the player to fight in the next challenging arena. Winning, time and in-game currency can also unlock chests which contain different types of cards, coins and gems.

The game is designed to ease the player into understanding the game world. Starting with learning how to battle and gathering knowledge about one’s resources (cards), battlefield (arena) and the various elements that inform victory such as the timing of card deployment, composition of cards, understanding their strengths and weaknesses and the behaviour of troops among many others. To support this, an accessible battle deck contains statistics, however, it is through emergent gameplay that one will understand how all the elements weave together.

In battle, the player will need to plan their game deck (they will have more cards than they can play with) while assessing the composition of their cards using anticipatory thinking, as they don’t know what the opponent’s cards contain. As each card is deployed, players are constantly reviewing their performance against others, reflecting on which troop card might fight better next time and how to increase its strength. In the two to three-minute battles, there are split-second decisions to be made when the opponent reveals their card; the player will counter and quickly assess whether the card is going to be used as defense or offense or a combination of both. This continuous assessment of priorities happens during battle as cards can be deployed within seconds of each other. Adding to the

complexity, the player needs to consider the timing of the card's elixir and randomness of the four cards handed from their deck. Post-battle, the player will reflect on the cards used, perhaps aiming to collect a more balanced composition for future battles. Outside of battle, the player will need to manage their resources of coins and gems, so they can contribute to battle success. They can be used to upgrade existing cards, unlock chests and others.

Though the goal of this tower defense game is simple, it requires strategic card composition, battle approach and overall management of resources to be successful. Gameplay strategies are built from experience—the training camp, learning by watching epic in-game battles and the ability to friendly-battle your clan mates without the consequence of losing trophies. These are designed to advance to advance player's skill and motivate them through losses (there will be many). The ability to form a clan with friends, communicate, ask and donate cards is a tremendous social motivator. Perhaps one of the most significant contributors of grit is the ability for a player to customize the strategy around their gameplay, given the many challenges that define success.

If a player actively seeks resources like blogs, books and videos to help them with their game, it demonstrates serious determination to win, plus, they are learning through multimodal literacies.



**Figure 7:** Clash Royale Score Cards

## Critical Thinking Score: 73%

### LEVEL 1

Instruction/guides

Non-timed gameplay;  
Zen mode without  
consequences

Limited choice of  
elements, actions,  
etc. that affect  
gameplay strategy

Simple/one-goal  
gameplay with  
predictable increase  
in complexity

In-game feedback on  
performance  
(just-in-time  
information, data  
sets, etc.)

### LEVEL 2

Some instructions;  
some emergent  
gameplay

Training mode  
(simulates  
competitive  
gameplay)

Customization of  
elements, actions,  
etc. that affect  
gameplay strategy

Multiple  
goals/considerations,  
increasing in challenge  
at pace with player  
experience; some  
predictability

In-game  
communication  
tools (chat, social  
tools, etc.)

### LEVEL 3

No instructions,  
fully emergent  
gameplay

Non-linear or  
player-directed  
gameplay  
(player controls to a  
certain extent, pace,  
timing, ability to  
explore, etc.)

Creation of elements,  
actions, world, etc.  
that affect gameplay  
strategy

Multiple goals with  
in-depth challenge;  
randomness;  
unexpected gameplay

External community  
resources (dedicated  
blog, YouTube,  
Twitch, forums, etc.)

POINTS 2

2

2

2

3

Total: 11/15 (73%)

## Grit Score: 80%

### LEVEL 1

Rewards, gifts,  
bonuses, cosmetic  
amusements, limited  
choice of add-ons  
(boosters, etc.)

Zen mode (relaxed  
gameplay without  
consequences)

Simple/one-goal  
gameplay with  
increasing challenges

Solo play;  
leaderboard

In-game feedback on  
performance  
(just-in-time  
information, data  
sets, etc.)

### LEVEL 2

Customization  
(elements, actions,  
etc.) that affect  
sustained interest,  
challenge of overall  
gameplay

Training mode  
(simulates  
competitive  
gameplay)

Multiple, increasing  
challenge at pace with  
player experience;  
scaffolding  
information from  
previous levels

Multiplayer;  
player vs. player

In-game  
communication  
tools (chat, social  
tools, etc.)

### LEVEL 3

Creation (elements,  
actions, world, etc.)  
that affect  
sustained interest,  
challenge of overall  
gameplay

Player-directed  
gameplay (player  
controls to a certain  
extent, the  
pace/timing, ability to  
explore, etc.)

In-depth challenge;  
randomness;  
unexpected

Ability to play with  
friends

External community  
resources (dedicated  
blog, YouTube,  
Twitch, forums, etc.)

POINTS 2

2

2

3

3

Total: 12/15 (80%)

## 8. Pac-Man 256

**Genre:** Endless Runner / Arcade

---

**Version:** Free

---

**Rating:** 4+

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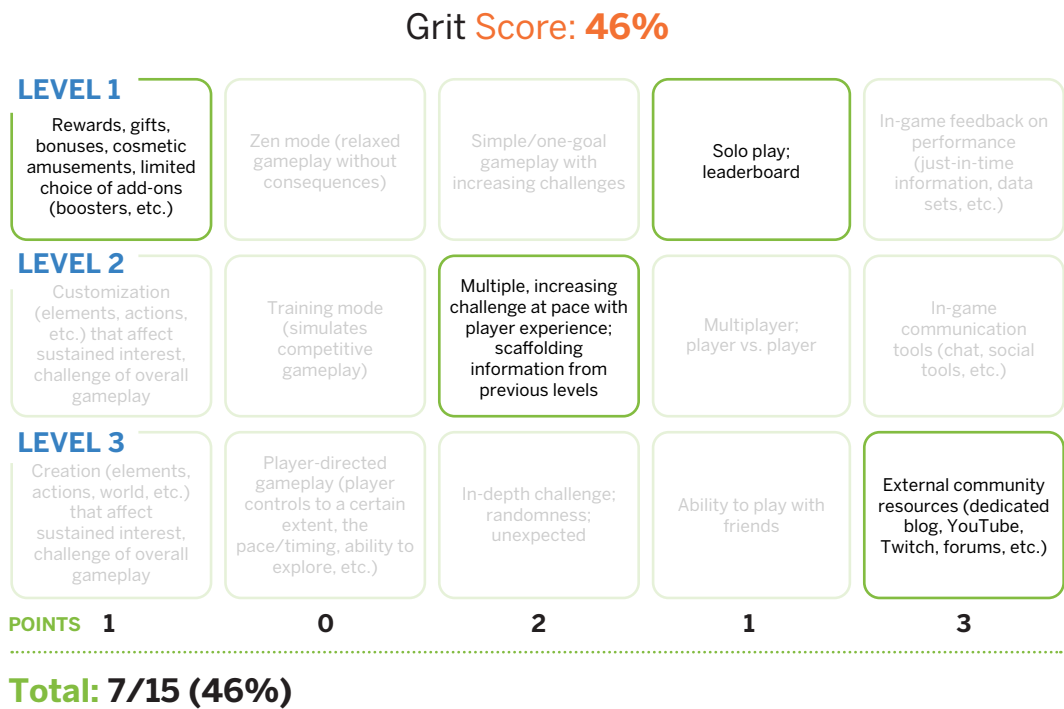
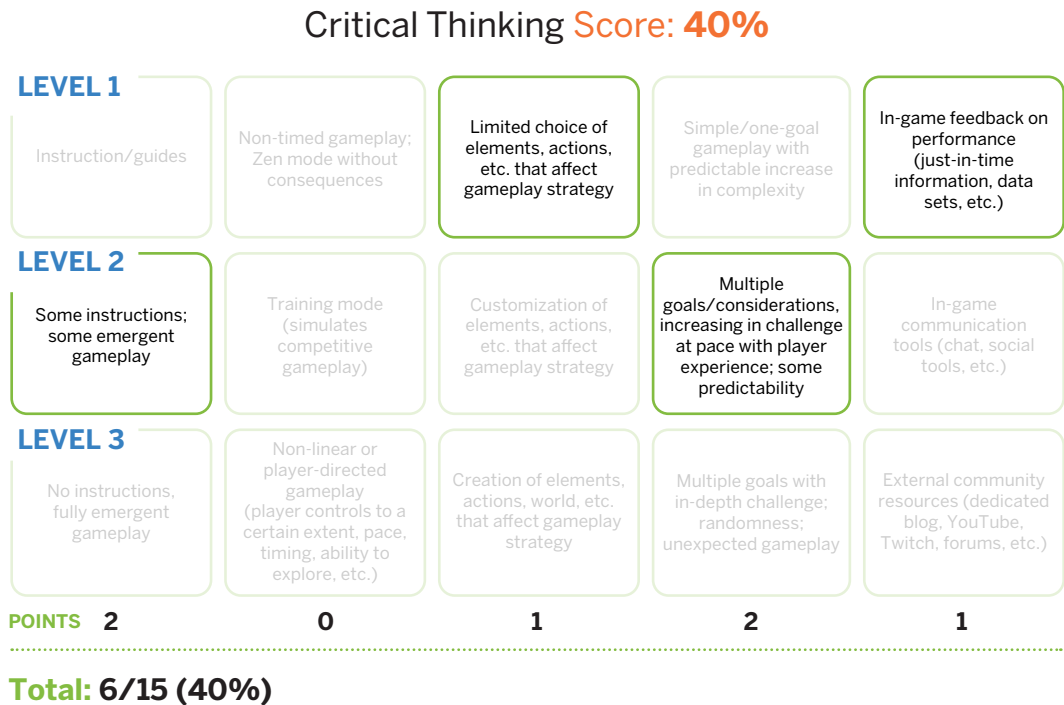
In this new take on the classic Pac-Man game, the game board scrolls up as Pac-Man eats pellets while avoiding ghosts and the 256 glitch. The glitch is a play on the infamous Pac-Man bug that prevents players from accomplishing level 256. It rises, covering the game board to catch Pac-Man, forcing the player to move up the board quickly.

While one can aimlessly wander about eating pellets, the player with a goal of achieving a high score or long chain of points needs to understand the use of multipliers like fruits and the behaviour of ghosts, using and upgrading boosters and the implications of completing pellet chains. This discovery is mostly emergent through gameplay especially if you have never played the classic version. Understanding these basics helps the player prioritize their moves, such as eating fruit first as it assigns a multiplier to everything that follows. Though it's a simple directional finger swipe, success is highly dependent on the player's quick reflexes, timing and looking ahead for a clear path for Pac-Man.

The different types of boosters to claim, game board theme variations and this endless arcade format are all designed to sustain interest. The main feature that might keep players returning is the challenge of outrunning ghosts while achieving a high score. With only one life to spare, the endless arcade format is designed to motivate the player to return in the hopes of proving themselves better in the next round. Those who have no interest in purchasing coins will be disappointed because you'll need to use coins to buy extra lives or watch a video advertisement which is disruptive to the game momentum.



**Figure 8:** Pac-Man 256 Score Card



## 9. Piano Tiles - Don't Tap the White Tile

**Genre:** Music / Arcade

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**Version:** Free

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**Rating:** 4+

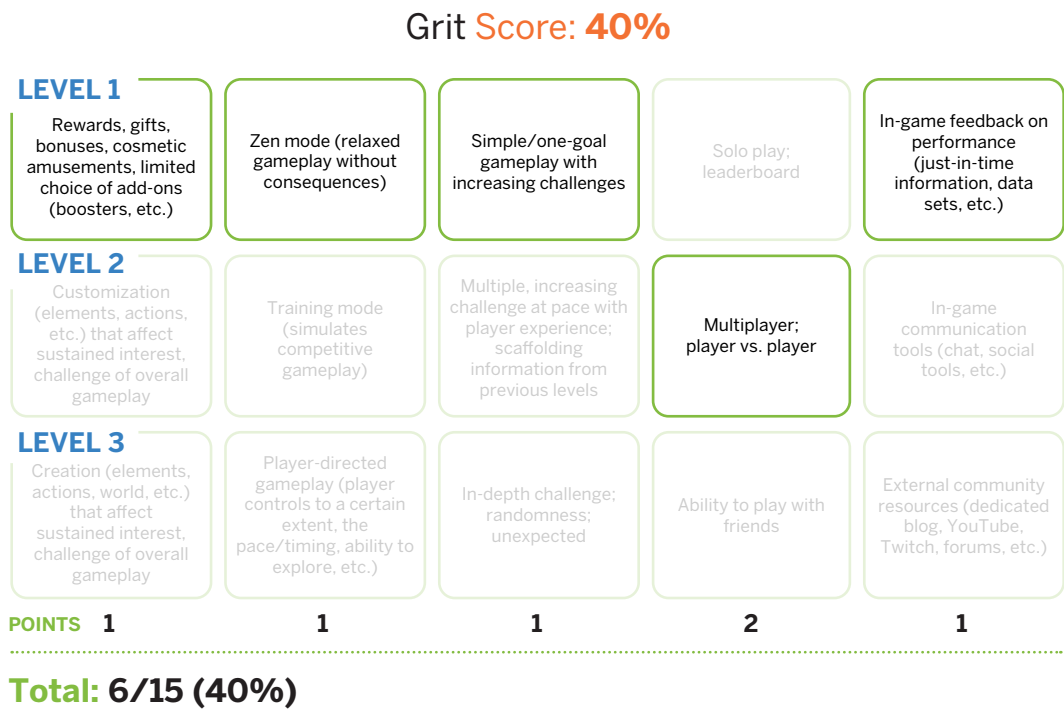
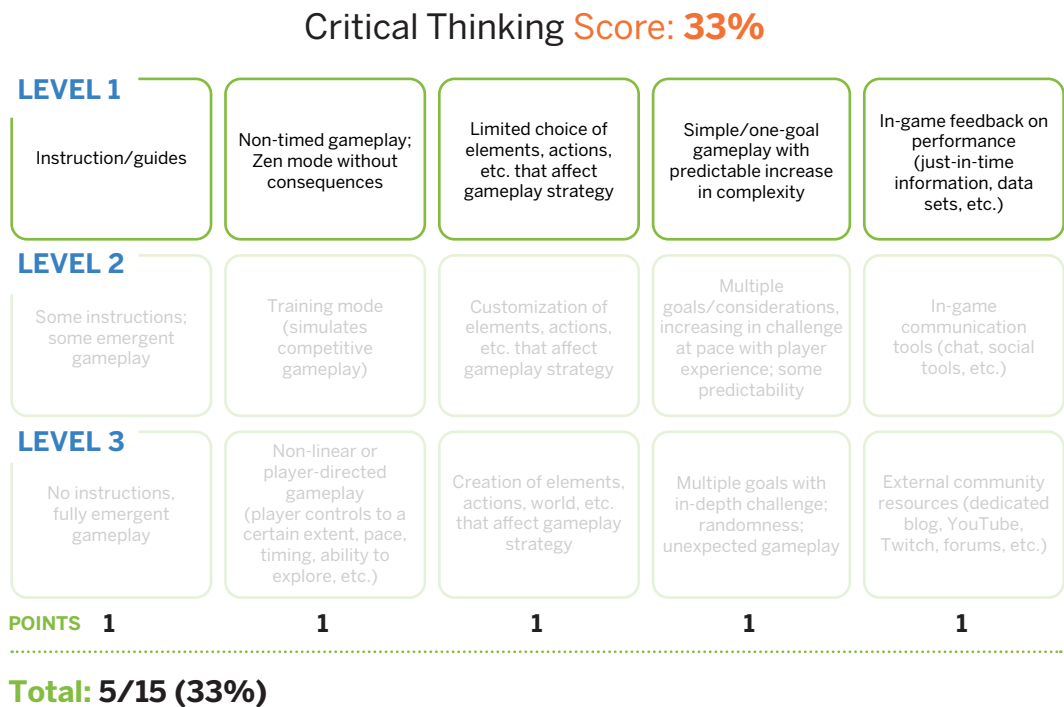
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Play a tune while tapping the black keys that scroll in increasing speeds. The Zen mode allows the player to practice their hand and eye coordination and experiment with the optimal finger position to avoid the white tiles. Various modes provide different challenges like increasing scroll speeds, placements of tiles and types of songs. This is a typical “twitch game” in which there are no deep strategies to be played out and success is based on the player’s reaction time.

As Piano Tiles come in classic, arcade, arcade+, battle, rush, Zen and relay, it allows the player to choose a personal style of play. It can also find a real-time player to complete with. Like most games, it also rewards the player for coming back daily, but these are not enough to sustain long-term interest to foster grit.



**Figure 9:** Piano Tiles (Don't Tap the White Tile) Score Cards





## 10. Fruit Ninja

**Genre:** Arcade (General)

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**Version:** Free

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**Rating:** 4+

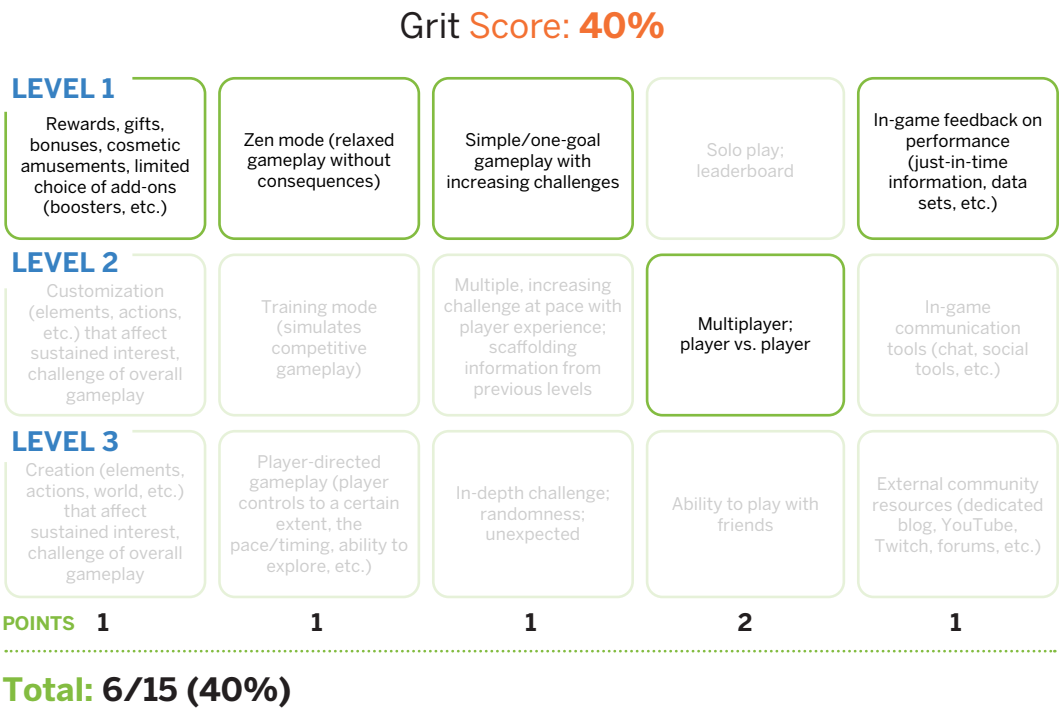
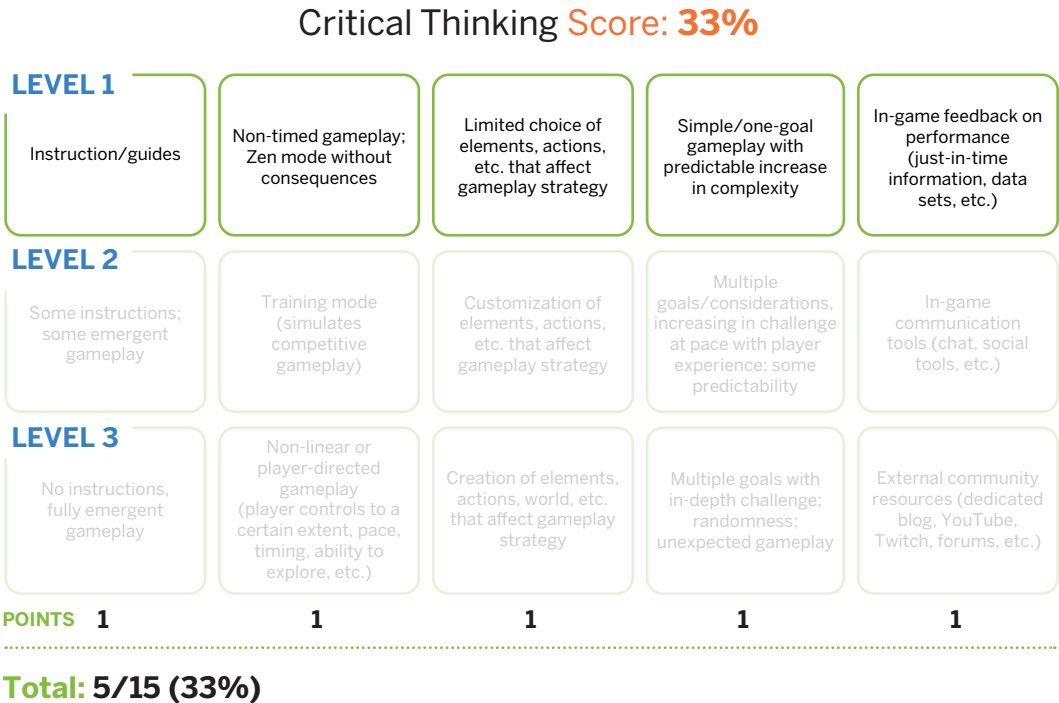
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With a simple goal of slicing as many fruits as possible while dodging bombs, this one-gesture game comes in several modes: classic, arcade, Zen, challenge, tournament and multiplayer. The Zen mode allows the player to practice their swiping skills without fear of exploding bombs, which ends gameplay. This game starts at a simple level and slowly increases the challenges by adding different types of fruit, changing the timing around when they appear and mixing it in with bombs. The knowledge building comes fast as there are only a few game elements and they're easy to understand. Success in the game comes from good timing, coordination of the player's swipes in relation to the moving objects, and knowing when you can create combos to create blitzes (bonus) and then extending them to gain extra points.

There are some options for customization such as choosing dojos or different blades, which yield bonus points, but these are acquired with starfruit, the game currency, which you accumulate by reaching levels or through in-app purchases. The variety of modes, ease of play, daily challenges, missions and some customization (without purchase) all aim to sustain the player's interest. They are, however, superficial designs and once the player tires of the one-gesture approach, they will surely move on to the next new game.



Figure 10: Fruit Ninja Score Cards



## 11. Minecraft Pocket Edition (PE)

**Genre:** Sandbox / Action Builder

**Version:** Paid

**Rating:** 9+

Dig (mine) and build (craft) all sorts of resources to survive in different biomes (terrains) and obstacles. Designed in an easy-to-manipulate 3D block-style world, the player is dropped into a random terrain like a forest or a desert and needs to mine it for resources to survive. Through self-directed exploration, the player learns the terrain's characteristics, what's available and therefore what can be crafted. Minecraft operates on a 20-minute day-night cycle. During the daytime, one needs to strategize how to gather food, find resources to make tools and shelter for initial survival. During nighttime, the world falls dark and hostile mobs spawn on the surface. If the player survives the night, a new day rises and defence mechanisms can be improved.

Minecraft comes with no instructions and can be intimidating at the start. The player is forced to gather information from the environment, behaviour of objects, and consequences of actions like mining, killing, crafting, tinkering and accidents (like drowning by falling into water). It's through emergent gameplay that one is able to construct their assumptions and concepts of the game's rules and norms.

The creative mode gives full access to the resource inventory like building materials, weapons, food, animals and more from which players learn to construct their own objects, contraptions, sprawling cities and other elements. Even as the entire inventory becomes available, the player still needs to understand relationships between resources (like 1 stick + 1 coal = torch), then break them into parts, prioritize and plan materials needed for a multi-stage construction like a roller coaster. After the analysis, the player will synthesize this information to create their own unique creation.

In survival mode, the player is without any resources and the need to acquire materials to create a shelter and defend oneself before nightfall is urgent. The process of knowledge gathering is heightened and ongoing analysis and reasoning happens throughout, from searching and understanding what new material combinations yield, to learning to combat nighttime zombies with weapons and objects. The collection of these inform the player how they might better design their shelter, weapons and avoid going hungry. The player can also decide to take on more challenges, like creating a nether portal, a lava ridden world where you can obtain rare resources (but watch out what you encounter in it).

With Minecraft, nothing happens without the player's input. They have to build their world. Such personalization is key to building true interest, which can turn into passion. It's no surprise that millions of kids have been enamored by this game. Additionally, the ability for friends to collaborate on building structures and defending themselves against the mobs encourages team collaboration. This game is fun to play in "multiplayer." While there might be no in-game instructions, Minecraft has one of the largest third-party communities where many have shared tips, tricks and unique creations that inspire many others.



**Figure 11:** Minecraft Score Cards

## Critical Thinking Score: 100%

### LEVEL 1

Instruction/guides

Non-timed gameplay;  
Zen mode without  
consequences

Limited choice of  
elements, actions,  
etc. that affect  
gameplay strategy

Simple/one-goal  
gameplay with  
predictable increase  
in complexity

In-game feedback on  
performance  
(just-in-time  
information, data  
sets, etc.)

### LEVEL 2

Some instructions;  
some emergent  
gameplay

Training mode  
(simulates  
competitive  
gameplay)

Customization of  
elements, actions,  
etc. that affect  
gameplay strategy

Multiple  
goals/considerations,  
increasing in challenge  
at pace with player  
experience; some  
predictability

In-game  
communication  
tools (chat, social  
tools, etc.)

### LEVEL 3

No instructions,  
fully emergent  
gameplay

Non-linear or  
player-directed  
gameplay  
(player controls to a  
certain extent, pace,  
timing, ability to  
explore, etc.)

Creation of elements,  
actions, world, etc.  
that affect gameplay  
strategy

Multiple goals with  
in-depth challenge;  
randomness;  
unexpected gameplay

External community  
resources (dedicated  
blog, YouTube,  
Twitch, forums, etc.)

POINTS 3

3

3

3

3

**Total: 15/15 (100%)**

## Grit Score: 100%

### LEVEL 1

Rewards, gifts,  
bonuses, cosmetic  
amusements, limited  
choice of add-ons  
(boosters, etc.)

Zen mode (relaxed  
gameplay without  
consequences)

Simple/one-goal  
gameplay with  
increasing challenges

Solo play;  
leaderboard

In-game feedback on  
performance  
(just-in-time  
information, data  
sets, etc.)

### LEVEL 2

Customization  
(elements, actions,  
etc.) that affect  
sustained interest,  
challenge of overall  
gameplay

Training mode  
(simulates  
competitive  
gameplay)

Multiple, increasing  
challenge at pace with  
player experience;  
scaffolding  
information from  
previous levels

Multiplayer;  
player vs. player

In-game  
communication  
tools (chat, social  
tools, etc.)

### LEVEL 3

Creation (elements,  
actions, world, etc.)  
that affect  
sustained interest,  
challenge of overall  
gameplay

Player-directed  
gameplay (player  
controls to a certain  
extent, the  
pace/timing, ability to  
explore, etc.)

In-depth challenge;  
randomness;  
unexpected

Ability to play with  
friends

External community  
resources (dedicated  
blog, YouTube,  
Twitch, forums, etc.)

POINTS 3

3

3

3

3

**Total: 15/15 (100%)**

## 12. Mimpi Dreams

**Genre:** Puzzle / Adventure / Platformer

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**Version:** Paid

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**Rating:** 9+

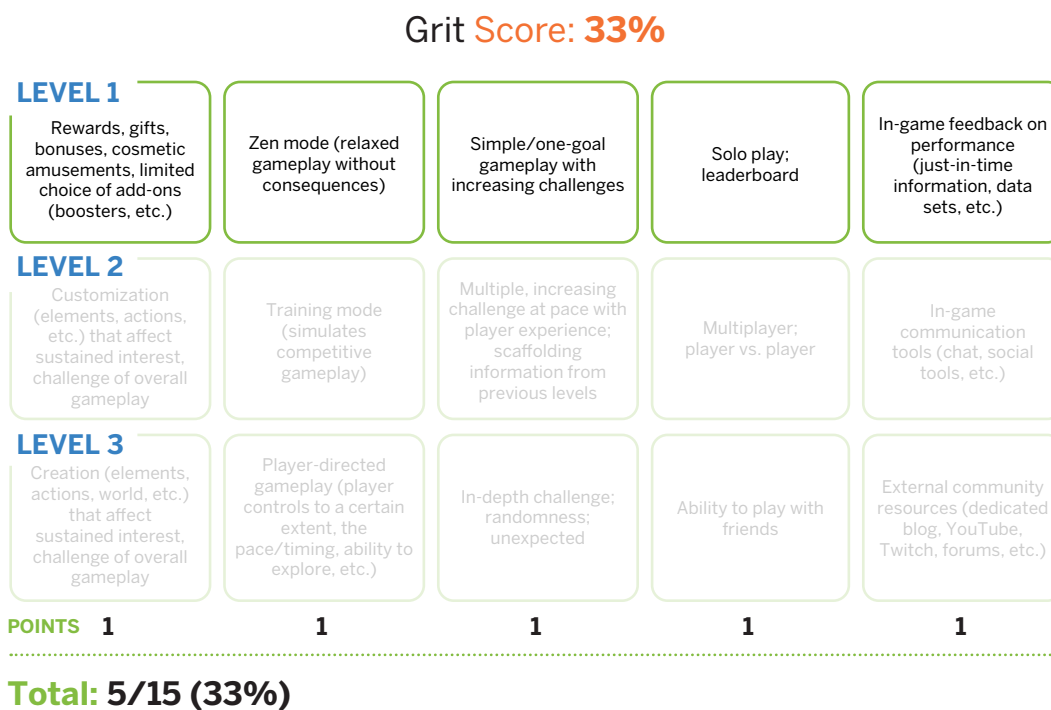
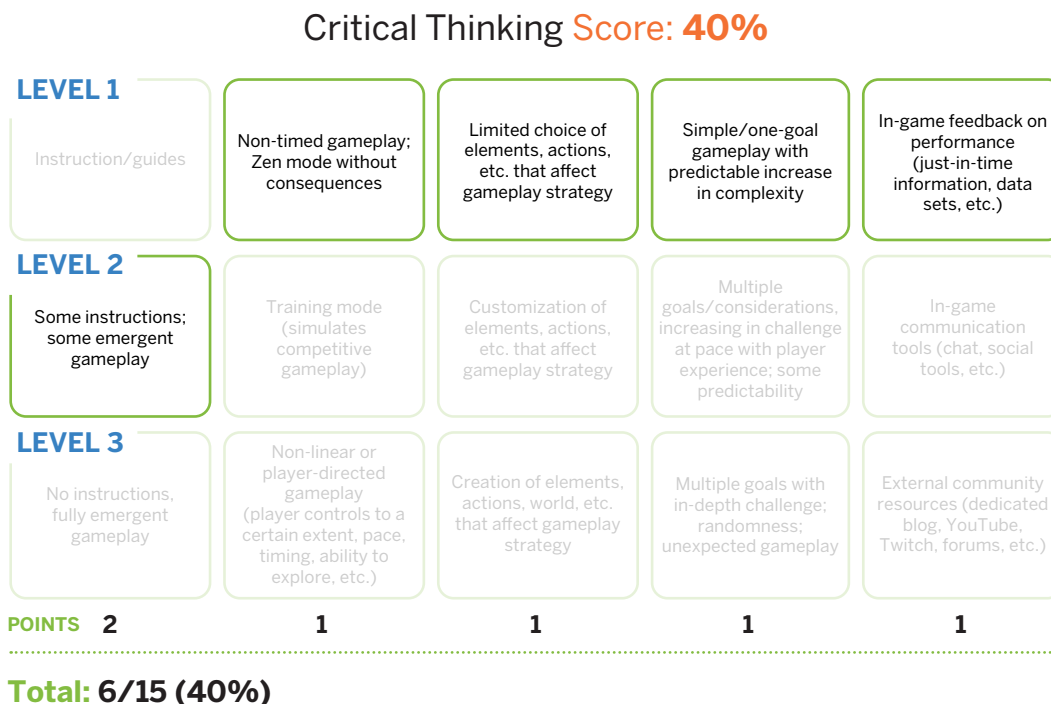
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Mimpi, a dog, explores different dream worlds in search for his doggie bed. Part platformer, part puzzle and adventure, this game requires quick reflexes and timing to move Mimpi in a series of coordinated jumps on platforms like clouds, logs and boats. It requires the player to analyze the visual clues and examine movable parts like switches and levers which trigger solutions within each world. Clues in the form of a light bulb are available but need to be collected. The game gives the player the luxury of time and unlimited lives to solve puzzles which are a great way to practice problem-solving through trial and error. Mimpi is a casual puzzle game and the challenges are relatively easy. It is linear as it forces the player to move along one path and solution only.

The game is player-directed and can be played at a relaxed pace. If the adventure puzzles are too easy, there are bones to collect for an extra challenge. There are also checkpoints which allow the player to return to the game at certain points in their journey without having to start at the beginning of the world. While the graphics are charming and the adventure theme is enjoyable, there are only five worlds to explore, and the puzzles may not provide enough challenge.



**Figure 12:** Mimpi Dreams Score Cards



## 13. Human Resource Machine

**Genre:** Puzzle / Logic

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**Version:** Paid

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**Rating:** 9+

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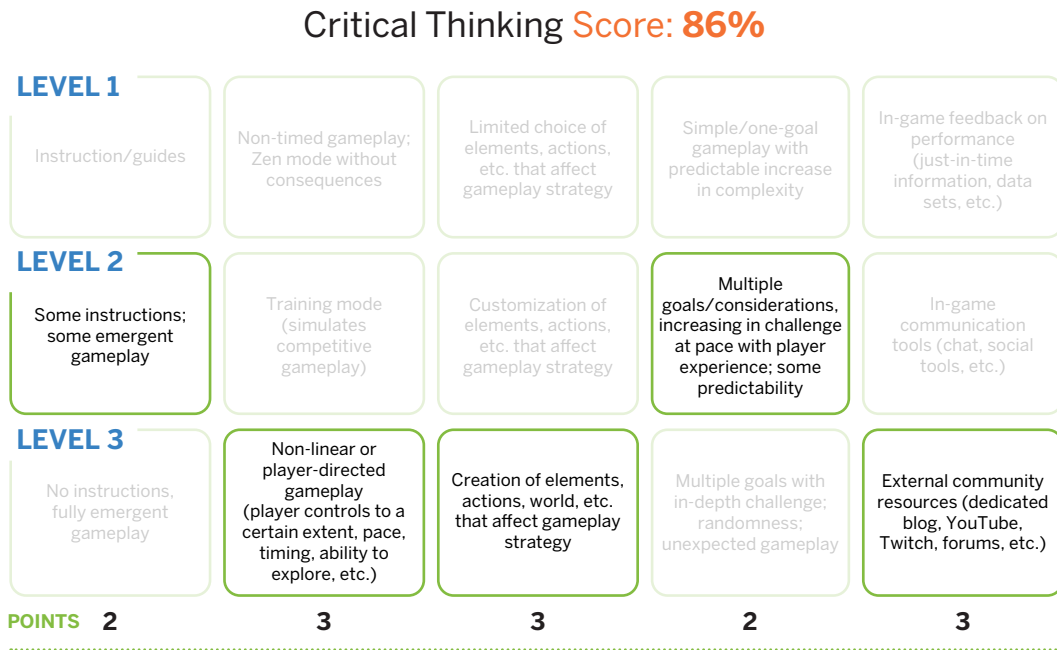
The player takes on the role of a new employee and starts at the mailroom floor. The boss assigns a task that the new employee must automate. If the work is completed, the employee moves on to the next floor, working his way up the corporate ladder. The automated tasks are a simple way to introduce the concepts of coding, however the player does not emerge learning to write code. The game is not and does not claim to be educational. As levels progress, new coding functions are added to previously learned commands.

The knowledge scaffolds nicely and is visually supported by the employee acting out the code, physically moving the variables (letters or numbers) like packages from the inbox, to the floor and outbox. There are no guides and instructions if you get stuck. The boss might offer some hints or examples, however it is through trial and error that the player will realize if the code works or not. If the code is wrong, you will immediately catch the employee executing the command incorrectly and adjust from there. There is no time limit and each level needs to be completed to move on to the next. As with real coding, the player learns about sequencing, logic, problem-solving and being able to string different concepts to create a new function (synthesis). The player does not need to know anything about coding to play this game, but patience and careful analysis are required to reach the corner office. The levels progress well with increasing challenges but can get frustrating if the player lacks the disposition of openness and willingness to experiment. As there are no time constraints, the player has the freedom to experiment until the command is functional. This game is by no means boring and it is supported by an engaging employee narrative.

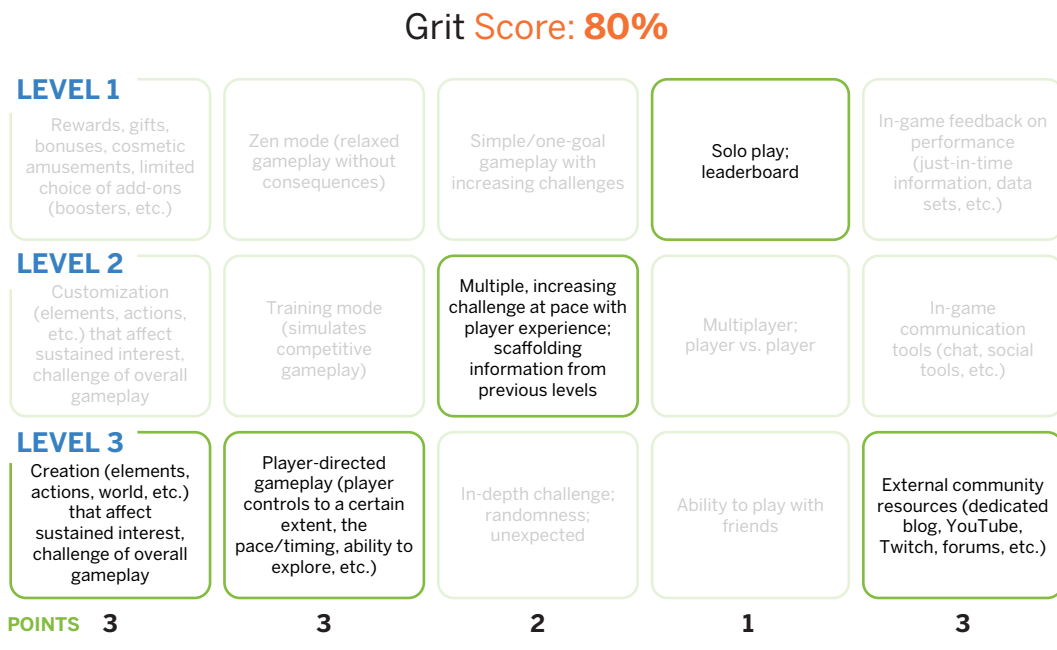




**Figure 13:** Human Resource Machine Score Cards



**Total: 13/15 (86%)**



**Total: 12/15 (80%)**

## 14. Stick Hero

**Genre:** Arcade / Physics

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**Version:** Free

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**Rating:** 4+

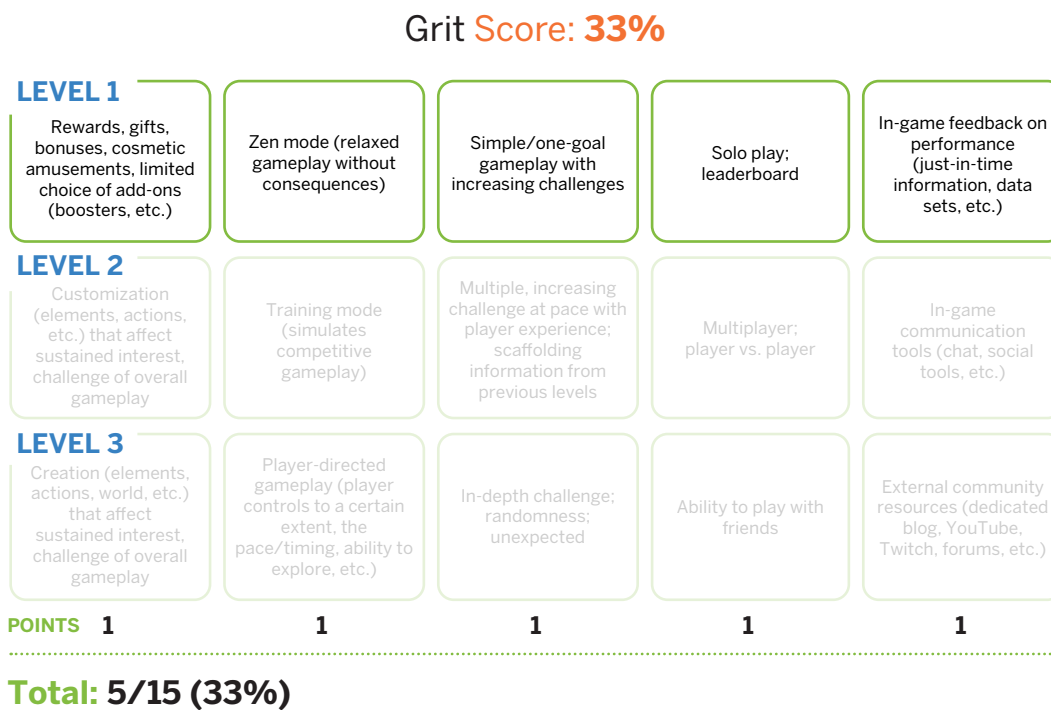
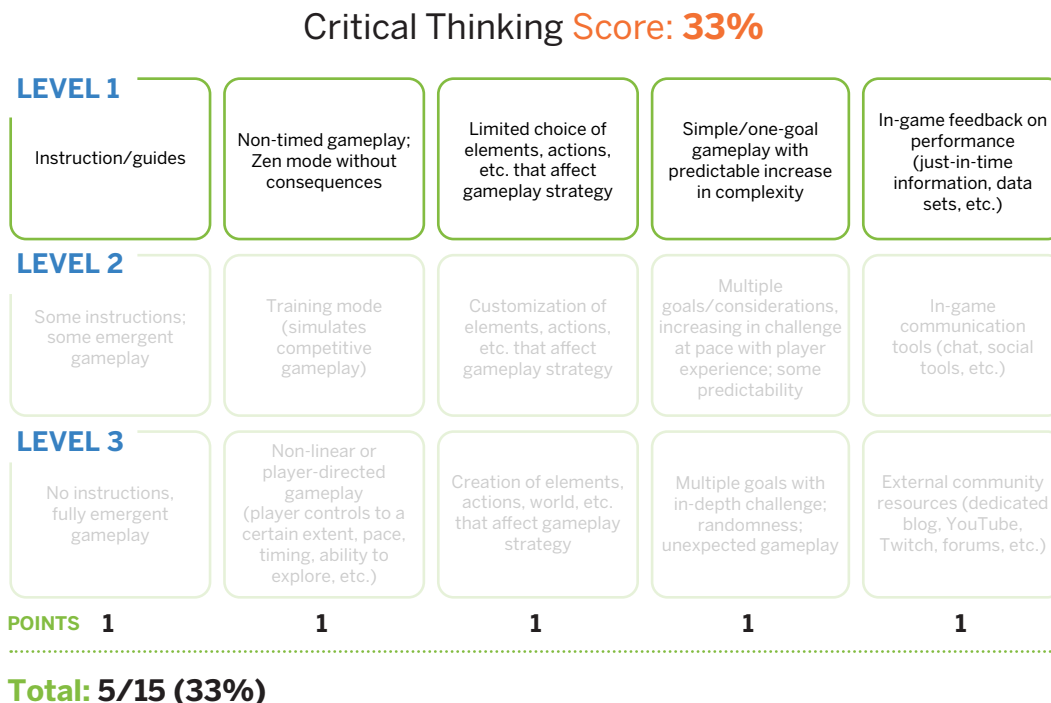
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Help a man cross platforms by stretching a stick to reach the next one. Use your visual estimation skills to determine the distance between platforms. If the stick is too long or short, the man falls. For an extra challenge, you can collect a cherry at the bottom of the stick by tapping the man to walk upside down. Other than estimation skills, a successful player needs to have quick reflexes to accurately stretch the stick and grab the cherry. Move along, there's nothing much here.

No doubt, you'll replay this game a few times perhaps because you have failed miserably and think you can do better next time. While that might work in the short term, the simplicity of the game does not foster anything that will drive serious passion or perseverance.



**Figure 14:** Stick Hero Score Cards



## 15. Plants vs. Zombies 2

**Genre:** Strategy / Tower Defence

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**Version:** Free

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**Rating:** 9+

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Defend your home and protect your brains from being eaten by zombies. Your yard is the playing field divided into five or six horizontal lines. Plant various types of crops to act as warriors against all kinds of invasive zombies.

The first game starts as an optional guided demonstration. The player needs to assess the game environment (the backyard, ancient Egypt or other worlds), strengths of each plant and its efficacy on different types of zombies (some block, attack or explode) and the timing of available plants versus the timing of zombies approaching. Plants have a “sun” value, which is collected by the player as the sun icon is released. When the plant’s sun value completes or recharges, only then can it be added to the gameplay. Similarly, zombies approach at varying speeds and waves. The player can get extra help by using plant food to strengthen its unique abilities or use boosters that freeze, flick or zap zombies out of the yard.

This game is about strategic selection and placement of plants in consideration of advancing zombies. An assessment of available resources and when to use them is crucial. The player is asked to make defensive and offensive decisions at all times during the invasion given the limitation of timing. As players will reflect on the need to have a garden-variety of plants, the game offers many options such as planting seeds to grow in the Zen garden (which take time or coins), unlock new plants (from gameplay experience or through coins). Although the game can be played without making in-app purchases, the play gets more challenging and you may have to grind it for days before you can earn boosters and unlock the help you need. There are many rewards for those who play often, including coins, unlocking levels, plants and mini-games. The worlds offer new and increasing challenges. As with most tower defence games, the customization of strategies for each play is what sustains the competitive player. Through Facebook, players can invite friends to play, send and receive gifts.



**Figure 15:** Plants vs. Zombies 2 Score Cards

## Critical Thinking Score: 60%

### LEVEL 1

Instruction/guides

Non-timed gameplay;  
Zen mode without  
consequences

Limited choice of  
elements, actions,  
etc. that affect  
gameplay strategy

Simple/one-goal  
gameplay with  
predictable increase  
in complexity

In-game feedback on  
performance  
(just-in-time  
information, data  
sets, etc.)

### LEVEL 2

Some instructions;  
some emergent  
gameplay

Training mode  
(simulates  
competitive  
gameplay)

Customization of  
elements, actions,  
etc. that affect  
gameplay strategy

Multiple  
goals/considerations,  
increasing in challenge  
at pace with player  
experience; some  
predictability

In-game  
communication  
tools (chat, social  
tools, etc.)

### LEVEL 3

No instructions,  
fully emergent  
gameplay

Non-linear or  
player-directed  
gameplay  
(player controls to a  
certain extent, pace,  
timing, ability to  
explore, etc.)

Creation of elements,  
actions, world, etc.  
that affect gameplay  
strategy

Multiple goals with  
in-depth challenge;  
randomness;  
unexpected gameplay

External community  
resources (dedicated  
blog, YouTube,  
Twitch, forums, etc.)

POINTS 2

0

2

2

3

**Total: 9/15 (60%)**

## Grit Score: 53%

### LEVEL 1

Rewards, gifts,  
bonuses, cosmetic  
amusements, limited  
choice of add-ons  
(boosters, etc.)

Zen mode (relaxed  
gameplay without  
consequences)

Simple/one-goal  
gameplay with  
increasing challenges

Solo play;  
leaderboard

In-game feedback on  
performance  
(just-in-time  
information, data  
sets, etc.)

### LEVEL 2

Customization  
(elements, actions,  
etc.) that affect  
sustained interest,  
challenge of overall  
gameplay

Training mode  
(simulates  
competitive  
gameplay)

Multiple, increasing  
challenge at pace with  
player experience;  
scaffolding  
information from  
previous levels

Multiplayer;  
player vs. player

In-game  
communication  
tools (chat, social  
tools, etc.)

### LEVEL 3

Creation (elements,  
actions, world, etc.)  
that affect  
sustained interest,  
challenge of overall  
gameplay

Player-directed  
gameplay (player  
controls to a certain  
extent, the  
pace/timing, ability to  
explore, etc.)

In-depth challenge;  
randomness;  
unexpected

Ability to play with  
friends

External community  
resources (dedicated  
blog, YouTube,  
Twitch, forums, etc.)

POINTS 2

0

2

1

1

**Total: 8/15 (53%)**



Play On!

